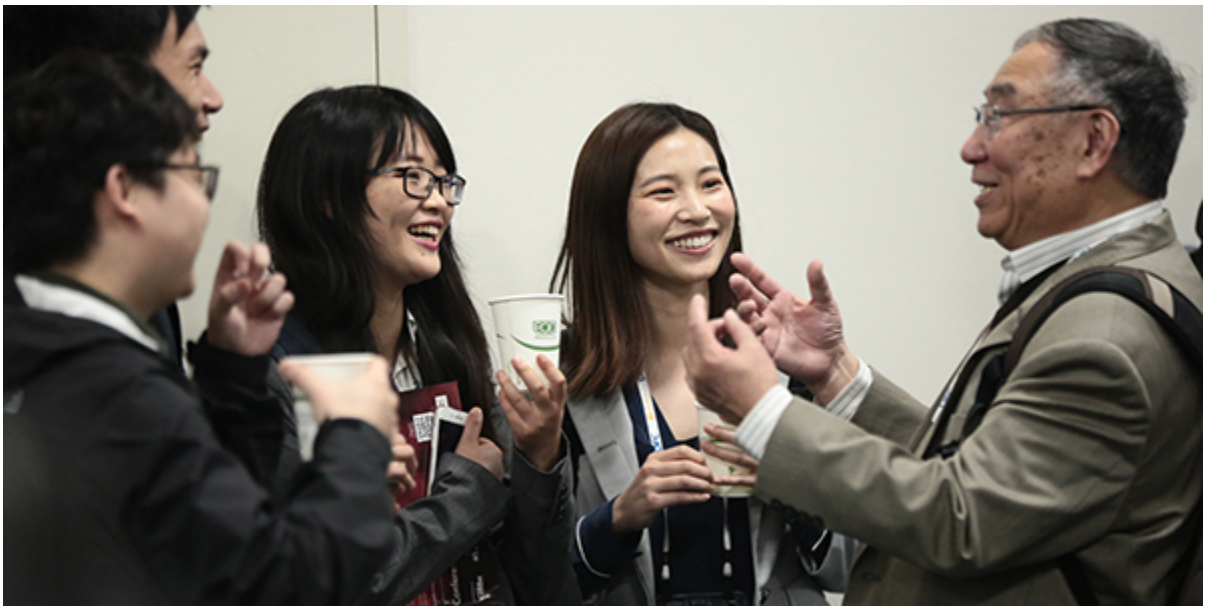
About

OFC

The Optical Networking and Communication Conference & Exhibition

Moscone Center, San Francisco, California, USA



CONFERENCE ARCHIVES

2020 – San Diego, California, USA

Program (PDF)
Conference Papers
Technical Sessions
Authors and Presiders

View Presentations

Previous Years

The Premier Annual Event for Telecom, Optical Communications and Data Center Optics, Reschedules to June 2021

OFC, the premier event in telecom and data center optics, will now take place 06 – 10, June 2021, at the Moscone Center, San Francisco, California, USA. The exhibition will be held 08 – 10, June 2021.

Considered the foremost gathering of leaders in academia, engineering and industry, OFC represents the entire optical communications ecosystem—from research to the marketplace, from components to systems and networks, technical sessions and an interactive exhibition.

The conference, originally scheduled for 28 March – 01 April 2021 in San Francisco, has rescheduled its dates to ensure a successful conference and exhibition experience for all participants, while also taking into consideration the health and safety of attendees and exhibitors.

“Since the 2020 conference and exhibition occurred, OFC’s co-sponsors, Steering Committee and Program Chairs have been meeting regularly to ascertain the likely impact of the current pandemic on the event,” said OFC 2021 Steering Committee Chair, Seb Savory, IEEE/Photonics Society, and University of Cambridge, UK.

“After careful consideration, having consulted various stakeholders, it became clear that the best solution at this point in time, was to shift the timing of OFC, from March to June. By moving the event to these new dates, we not only increase the likelihood that we will be able meet together in person and so able to enjoy both the usual onsite programming and exhibits, but it also better aligns the timing of OFC with other major conferences that have shifted their timing in response to the pandemic.”

OFC 2021 will introduce a blended in-person and virtual format to provide attendees the greatest opportunity to reach customers, reconnect with colleagues and demonstrate innovative solutions to this community. The high-caliber plenary program will include live onsite presentations from three distinguished speakers on the latest research and applications in optical fiber communication.

The OFC 2021 technical program will continue to explore the latest in optical communications innovation, data-center connectivity, machine learning/artificial intelligence (AI), applications of optical networks in 5G and cloud computing. The new deadline for paper submissions is 26 January 2021.

Health and safety measures will be implemented at the Moscone Center and all associated properties. Further details about the Call for Papers, speaking submissions, the conference and exhibition will be forthcoming. Please monitor the OFC website for updates.

The traditional OFC conference schedule will resume in March 2022 to maintain continuity for attendees in planning and preparing for the event.

Future Dates

Year	Dates	Location
2022	06 - 10 March	San Diego, CA
2023	05 - 09 March	San Diego, CA
2024	24 - 28 March	San Diego, CA

Committee

Committees

General Chairs

Po Dong, *II-VI Incorporated, USA*
Jun-ichi Kani, *NTT, Japan*
Chongjin Xie, *Alibaba, USA*

Program Chairs

Ramon Casellas, *CTTC, Spain*
Chris Cole, *II-VI Incorporated, USA*
Ming-Jun Li, *Corning, USA*

Subcommittees

Track D: Components, Devices and Fiber

D1: Advances in Prototypes and Product Developments of Components and Subsystems for Data Centers and Optical Networks
Hanxing Shi, *Liturex, USA, Subcommittee Chair*
Jiashu Chen, *II-VI (Finisar), USA*
Long Chen, *Acacia, USA*
Friedel Gerfers, *Technische Universität Berlin, Germany*
Fred Kish, *North Carolina State Univ., USA*
Di Liang, *Hewlett Packard Enterprise, USA*
Andreas Matiss, *Corning, Germany*
Reza Motaghian, *Amazon, USA*
Hideyuki Nasu, *Furukawa, Japan*
Zuowei Shen, *Google, USA*
Min Sun, *Tencent, China*
Jian Wu, *Beijing Univ. of Posts and Telecommunications, China*

D2: Passive Optical Devices for Switching and Filtering
Richard Jensen, *H+S Polatis Inc., USA, Subcommittee Chair*

Glenn Bartolini, *II-VI, USA*
Qixiang Cheng, *Univ. of Cambridge, UK*
Giampiero Contestabile, *Scuola Superiore Sant Anna di Pisa, Italy*
Kazuhiro Ikeda, *National Institute of Advanced Industrial Science and Technology (AIST), Japan*
Yuqing Jiao, *Eindhoven Univ. of Technology, Netherlands*
Nicolas Riesen, *Univ. of South Australia, Australia*
Lucas Soldano, *Italy*
Cheryl Source-Agaskar, *MIT Lincoln Labs, USA*
Yikai Su, *Shanghai Jiao Tong Univ., China*
Kenya Suzuki, *NTT Device Technology Laboratories, Japan*
Ming Wu, *Univ. of California Berkeley, USA*
Yu Yu, *Wuhan National Lab for Optoelectronics, China*

D3: Active Optical Devices and Photonic Integrated Circuits
Yasuhiro Matsui, *II-VI Inc., USA, Subcommittee Chair*
Tomoyuki Akiyama, *Fujitsu Limited, Japan*
Gloria Hoefler, *Infinera, USA*
Hai-Feng Liu, *HG Genuine, China*
Argishti Melikyan, *II-VI Inc., USA*
Geert Morthier, *Ghent Univ. – IMEC, Belgium*
Martin Schell, *Fraunhofer Institut, Germany*
Matt Sysak, *Ayar Labs, USA*
Mitsuru Takenaka, *The Univ. of Tokyo, Japan*
Michael Tan, *Hewlett Packard, USA*
Erman Timurdogan, *Analog Photonics, USA*

D4: Fiber and Propagation Physics
Tetsuya Hayashi, *Sumitomo Electric Industries, Ltd., Japan, Subcommittee Chair*
Rodrigo Amezcua Correa, *Univ. of Central Florida, USA*
Peter Andrekson, *Chalmers Univ. of Technology, Sweden*
Cristian Antonelli, *Univ. of L'Aquila, Italy*
Xin Chen, *Corning Research & Development Corp., USA*
Louis-Anne de Montmorillon, *Prysmian Group, France*
Lara Garret, *Subcom, USA*
Eric Numkam Fokoua, *Univ. of Southampton, UK*
Roland Ryf, *Nokia Bell Labs, USA*
Taiji Sakamoto, *NTT Corporation, Japan*
Benyuan Zhu, *OFS Laboratories, USA*

D5: Fiber-optic and Waveguide Devices and Sensors
Francesca Parmigiani, *Microsoft, UK, Subcommittee Chair*
Raja Ahmad, *OFS Laboratorie, USA*

Xiaoyi Bao, *Univ. of Ottawa, Canada*
Yongmin Jung, *Univ. of Southampton, UK*
Sergio Leon-Saval, *Univ. of Sydney, Australia*
Chigo Okonkwo, *Technische Universiteit Eindhoven, Netherlands*
Chester Shu, *The Chinese Univ. of Hong Kong, Hong Kong*
Hidehisa Tazawa, *Sumitomo Electric Industries Ltd, Japan*
Michael Vasilyev, *Univ. of Texas, USA*
Joel Villatoro, *Univ. of the Basque Country, Spain*
Yinying Wang, *Jinan Univ., China*

Track S: Systems and Subsystems

S1: Digital Subsystems and Systems for Data Centers

Masahito Tomizawa, *NTT, Japan, Subcommittee Chair*
Sai Chen, *Alibaba Group, China*
Madeleine Glick, *Columbia University, USA*
Yue-Kai Huang, *NEC Laboratories, Japan*
Fotini Karinou, *Microsoft Research Ltd, USA*
Hoon Kim, *National Univ. of Singapore, Singapore*
Theodor Kupfer, *Cisco Systems, USA*
Xiaodan Pang, *KTH Royal Institute of Technology, Sweden*
Stephen Ralph, *Georgia Tech, USA*
Norman Swenson, *Norman Swenson Consulting, USA*
Hongbin Zhang, *Acacia Communications, USA*

S2: Optical, Photonic and Microwave Photonic Subsystems

Daniel Blumenthal, *Univ. of California Santa Barbara, USA, Subcommittee Chair*
Titziana Cones Bond, *LLNL, USA*
Maurizio Burla, *ETH Zurich, Switzerland*
Fumio Futami, *Tamagawa Univ., Japan*
Hao Hu, *DTU Fotonik, Denmark*
Lu Li, *TE SubCom, USA*
David Marpaung, *Univ. of Twente, Netherlands*
Ana Pejkic, *Univ. of California San Diego, USA*
Ben Puttnam, *NICT Japan, Japan*
Mary Salit, *Honeywell, USA*
Radan Slavik, *Univ. of Southampton, UK*
Dawn Tan, *Singapore Univ. of Technology and Design, Singapore*

S3: Radio-over-fiber, Free-space and Sensing Subystems and Systems

Mohamed-Slim "Slim" Alouini, *King Abdullah Univ. of Science & Tech (KAUST), Saudia Arabia,*

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Nan Chi, *Fudan University, China*
Chi Wai Chow, *National Chiao Tung University, Taiwan*
Baris Erkmen, *Google-X, USA*
Volker Jungnickel, *Fraunhofer, Germany*
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Luca Palmieri, *Universita degli Studi di Padova, Italy*
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Morio Toyoshima, *NICT, Japan*
Stefan Wolf, *Infinera, USA*

S4: Digital and Electronic Subsystems
Xi (Vivian) Chen, *Nokia, USA, Subcommittee Chair*
Neng Bai, *Facebook, USA*
Hussam Batshon, *NEC Laboratories Americas, Inc., USA*
Hung-Chang Chien, *Inphi, USA*
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Takahito Tanimura, *Hitachi Ltd., Japan*
Xiaoxia Wu, *SpaceX, USA*
Fan Zhang, *Peking Univ., China*
Liang Zhang, *Huawei Technologies, Germany*

S5: Digital Transmission Systems
Oleg Sinkin, *TE SubCom, USA, Subcommittee Chair*
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Werner Klaus, *National Inst of Information & Comm Tech, Japan*
Rui Lin, *Chalmers University of Technology*
Hisao Nakashima, *Fujitsu Limited, USA*
Marco Secondini, *Scuola Superiore Sant Anna di Pisa, Italy*
Kohki Shibahara, *NTT Network Innovation Laboratories, Japan*
Jianjun Yu, *Fudan University, USA*

Track N: Networks, Applications and Access

N1: Advances in System, Network and Service Developments and Field Trials in Commercial Data Centers and Networks

Steve Grubb, *Facebook, USA, Subcommittee Chair*
Mei Du, *Tata Communications, USA*
Frank Effenberger, *Futurewei, USA*
Qian Hu, *Nokia, USA*
Praveen Kumar, *Nokia Solutions And Networks Holdings Singapore Pte Ltd, Singapore*
Priyanth Mehta, *Ciena, USA*
Georg Mohs, *Subcom, USA*
Pascal Pecci, *ASN, France*
Albert Rafel, *BT, UK*
Shuto Yamamoto, *NTT, Japan*
Sheldon Walklin, *Nokia, USA*
Xiang Zhou, *Google, USA*

N2: Optical Networking for Data Center and Computing Applications

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Hideaki Furukawa, *National Institute of Information and Communications Technology (NICT), Japan*
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Georgios Zervas, *Univ. College London, UK*

N3: Architectures and Software-defined Control for Metro and Core Networks

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Gangxiang Shen, *Soochow Univ., China*

Jane M. Simmons, *Monarch Network Architects, USA*
Hidenori Takahashi, *KDDI Research, Inc., Japan*
Takafumi Tanaka, *NTT Network Innovation Laboratories, Japan*
Christine Tremblay, *École de Technologie Supérieure, Montréal, Canada*

N4: Optical Access Networks for Fixed and Mobile Services
Elaine Wong, *Univ. of Melbourne, Australia, Subcommittee Chair*
Liang Du, A*mazon Web Services, USA*
Michael Freiberger, *Verizon, USA*
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Marco Ruffini, *Trinity College, Ireland*
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Guo Yong, *ZTE, China*
Junwen Zhang, *Fudan University, China*

N5: Market Watch, Network Operator Summit & Data Center Summit (Invited Program)
Loukas Paraschis, *Infinera, USA, Subcommittee Chair*
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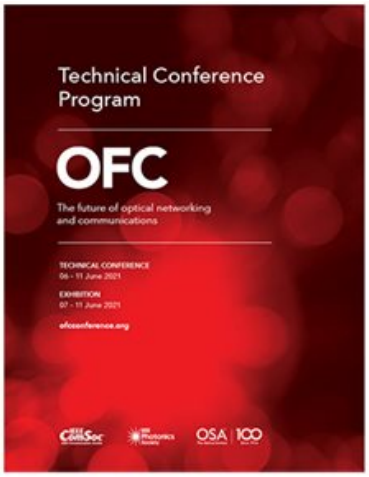
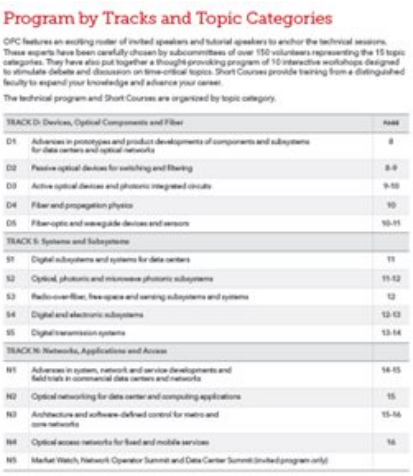
Program & Speakers





Program by Tracks and Topic Categories

OFC features an exciting roster of invited speakers and tutorial speakers to anchor the technical sessions. These experts have been carefully chosen by subcommittees of over 150 volunteers representing the 15 topic categories. They have also put together a thought-provoking program of 10 interactive workshops designed to stimulate debate and discussion on time-critical topics. Short Courses provide training from a distinguished faculty to expand your knowledge and advance your career.

The technical program and Short Courses are organized by topic category.

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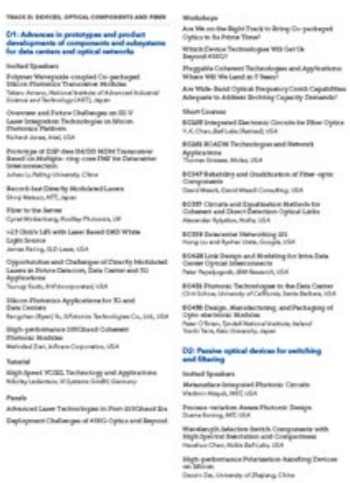

An All-Virtual Format in 2021

OFC, the premier event in telecom and data center optics, will be held in an all-virtual format **Sunday, 06 June to Friday, 11 June 2021.**

About the Virtual Technical Conference

The new format accommodates speakers and attendees across the globe with content presented live online and recorded for on-demand viewing. Technical sessions will be scheduled throughout the day to accommodate live participation from many geographic regions.

The virtual format impacts how presentations are delivered, not what is presented. The breadth and depth of the technical conference will remain intact with all sessions presented virtually.

What Will Be Presented Virtually?

- All technical sessions (including invited and tutorial speakers and contributed oral and poster presentations)
- Plenary Session, Workshops, Symposia and Special Sessions
- Half-day Short Courses that enhance your knowledge on important topics (additional registration fee)
- OFC Demo Zone

Hear Invited and Peer-Reviewed Presentations in Key Topic Areas

- Active optical devices and photonic integrated circuits
- Advances in prototypes and product developments of components and subsystems for data centers and optical networks
- Advances in system, network and service developments and field trials in commercial data centers and networks
- Architectures and software-defined control for metro and core networks
- Digital subsystems and systems for data centers
- Digital and electronic subsystems
- Digital transmission systems
- Fibers and propagation physics
- Fiber-optic and waveguide devices and sensors
- Optical access networks for fixed and mobile services
- Optical networking for data center and computing applications
- Optical, photonic and microwave photonic subsystems
- Passive optical devices for switching and filtering
- Radio-over-fiber, free-space and sensing subsystems and systems

Plenary Speakers

Yiqun Cai

Vice President, Alibaba Group, China

Talk: Hammers and Nails: How Technologies and Applications Drive the Evolution of Networking in Alibaba

People tend to view technologies as hammers and applications as nails. Problems found in development and operations are always met with the latest technology. In this talk, we will review how cloud computing evolves in Alibaba to become the foundation of our infrastructures, and share our experience in building networks to enable this transition.

About the Speaker

Yiqun Cai is a veteran in the networking industry, with over 25 years of experience in engineering and management.

He is currently a vice president in Alibaba Group. In this role, he leads the team that is responsible for the research, development, planning and operation of the networking infrastructure supporting all the business units of Alibaba Group and its affiliated companies.

Before joining Alibaba Group in 2016, he was with Microsoft as a Partner Engineer, working in the Windows Azure networking group for four years. In addition to many contributions to improve Windows Azure networking infrastructure, he also helped create the Express Route service.

Prior to Microsoft, he was a Distinguished Engineer at Cisco Systems, Inc. where he spent nearly 15 years. He was responsible for delivering many successful IP routing technologies and platforms. Before Cisco, he worked for Bell Northern Research in Ottawa for more than three years, primarily focusing on developing the very first generation of IP routing platforms of the company.

He graduated with a Bachelor of Science degree from Fudan University in Shanghai, China, and a Master of Science degree from the University of Alberta in Edmonton, Alberta, Canada, both in computer science. In his early days as an engineer, he was very active in the IETF and is the primary author or co-author of more than 10 Internet RFCs. He also owns a number of US patents in the area of networking.

Young-Kai Chen

Program Manager, Microsystems Technology Office, DARPA, USA

Talk: Symbiotic Perspective of Photonics and Artificial Intelligence

Over the past decades, tremendous advances in photonics and artificial intelligence have changed our life in the real world as well as in the virtual space. This talk will survey and explore a strong coalescence of photonics and artificial intelligence to enable next generation of communications and computing.

About the Speaker

In his current role at DARPA, Young-Kai (Y.K.) Chen supports R&D programs in millimeter-wave electronics, advanced photonic devices and edge sensors with embedded artificial intelligence.

Before joined DARPA in 2017, he was a Senior Director at Nokia Bell Labs supporting research groups to explore high speed electronics and optoelectronics for advanced wireless and optic fiber communication networks.

Chen and his teams had contributed to several successful transitions of innovative researches into commercial products and applications. For example, he developed and supported first commercial integrated DFB-EAM devices with a manufacturable selective-area growth technique in 1994. He led the group to implement silicon-based front end ICs for millimeter-wave point-to-point backhaul radios for 3G/4G/5G wireless base stations. He and his team explored the coherent optical receivers and launched the first commercial 100Gbps optical transponders in 2011. He and his team also developed silicon photonics ICs for microwave photonics and 100G data links from 2000 to 2017.

Chen received his PhD degree from Cornell University in 1988. He was an Adjunct Professor at Columbia University, National Taiwan University and National Chiao Tung University. He is a Fellow of Bell Labs, IEEE and OSA, a member of the Academia Sinica and National Academy of Engineering, and a recipient of the IEEE David Sarnoff Award and Edison Patent Award.

Nancy Shemwell

Chief Operating Officer, Trilogy Networks, USA

Talk: Industrial Revolution 4.0 — Gone Country

Unlocking the promise of technology during the Industrial Revolution 4.0 presents new opportunities and challenges throughout the modern world. But, no industries could be more substantially impacted then those of

Agriculture and Energy. The benefits of advanced automation, through the likes of industrial IoT, AI and ML, will forever change today's landscape. Faced with a projected shortage of food over the next 30 years, governments, the agriculture industry and technology outlets are working together to develop, fund and deploy Precision Agriculture solutions allowing the farms of tomorrow to double their production without an additional acreage, or incremental water. Likewise, similar initiatives are taking place in the Energy sector.

The speed of change and the onset of new technologies and applications like 5G open up these possibilities. However, these industries exist in traditionally underserved markets where the "digital divide" is real and limits today's progress. Trilogy Networks has recognized these conflicting dynamics and has made it their mission to provide 1,500,000 miles of distributed cloud support and applications across rural America. The Rural Cloud Initiative, with over 60 technology and rural carrier partners coordinating the deployment of distributed cloud networks, will bring the technology platforms required to run advanced solutions software and hardware and create an ecosystem. This talk will discuss this initiative and the groundbreaking solutions being deployed.

About the Speaker

In her current role at Trilogy Networks, Nancy Shemwell is responsible for guiding the company's ongoing growth and executing the founders' vision to deploy 1.5 million square miles of edge compute capability across rural America, providing the essential infrastructure for 5G, agriculture and energy solutions.

Prior to joining Trilogy Networks, Shemwell was COO of the IoT Community, the largest global IoT industry thought leader association.

A three-time Chief Executive Officer, she recently served as the Chief Executive Officer of entegra technologies, inc., recruited to migrate this early stage, ruggedized tablet company to provider of fully integrated portfolio of cyber security solutions for mission critical, industrial control systems (ICS). With a 20-year track record of driving high performance transformational global organizations, Shemwell has been Ranked #93 in ExecRank's "Top CSO Rankings" from 15,000 Chief Sales Officers and C-Level executives in the United States. She has also been recognized as a Finalist for 2015 D CEO M&A of the Year Award, Semi-finalist, 2018 Emerging Technology Tech Titan CEO of the Year and named a 2018 Phenomenal Women by Texas Wall Street Women.

Shemwell has previously held a variety of senior positions with global business responsibilities including assignments in Europe and North America. Her experience covers a broad spectrum of general management,

sales and marketing roles in rapidly developing markets. Previous positions include that of Chief Operating Officer and owner of DataSpan, President and CEO of Multi-Link, President and CEO of Jovial Test Equipment, EVP at Extreme Networks, EVP at Symmetricom and a 16-year career with Nortel Networks where she held titles of President, Micom Communications Corporation (a Nortel subsidiary), Vice President Business Segments, Vice President Sales and Marketing Wiltel (Nortel's largest enterprise distributor) and Director of Marketing for Europe, Middle East and Africa.

Shemwell holds a Bachelor of Business Administration from Baylor University and a Master of Science in Business Administration from Texas A&M. She was named to the VoodooVox, Inc. (VVX – TSX) Board of Directors in 2006, and the NTXRCIC in 2012. She also serves as the Chair of the entegra technologies Board of Advisors, appointed in 2018 to the Board of Advisors of IoT Communities. hemwell also serves on the Associate Board at the SMU Cox School of Business and is a member of the National Association of Corporate Directors and Women Corporate Directors.

Plenary Speakers Live Q&A

Immediately following the plenary talks on Tuesday, 08 June beginning 08:00 PDT, each speaker will participate in a live Q&A discussion on their groundbreaking initiatives -- Yiqun Cai, Alibaba Group, China; Young-Kai Chen, Microsystems Technology Office, DARPA, USA; and Nancy Shemwell, Trilogy Networks, USA. They will join OFC General Chairs Jun-ichi Kani, Po Dong and Chongjin Xie, OFC Program Chair Ramon Casellas, OSA Senior Industry Advisor Tom Hausken and OSA Science Advisor C. Randy Giles and registrants for in-depth talks on the evolution of networking, photonics and AI and deployment of edge cloud for rural areas.

Demo Zone

Organizers:
Paolo Monti, *Chalmers University of Technology, Sweden;* Achim Autenrieth, *ADVA Optical Networking SE, Germany;* Nan Chi, *Fudan University, China;* Liang Du, A*mazon Web Services, USA;* Manya Ghobadi, *Massachusetts Institute of Technology, USA*
Yongmin Jung, *University of Southampton, UK;* Ricardo Martinez, *Centre Tecnològic Telecomunicacions Catalunya, Spain*

OFC Virtual Demo Zone
The OFC Demo Zone features demonstrations of research projects and proof-of-concept implementations in the space of optical communication devices, systems, and networks.

This year's Demo Zone will be presented in an all-virtual format and follow the technical session style where each presenter will have 10 minutes to pitch their Demo, followed by Q& A. Following the live presentation, each presenter will provide a longer video displaying their Demo in action. In addition, each Demo video will have a dedicated page with a chat window for further engagement with the presenter.

The 2021 OFC Demo Zone covers topics ranging from SDN/NFV and software tools/functions to software and hardware aspects on all conference topics.

Please see below for a list of Demo Zone presenters:

Part 1: Monday, 7 June; 05:00 - 07:00 PDT (UTC-07:00)
Michaela Svaluto Moreolo, *Center Tecnològic de Telecom de Catalunya, Spain*
Demonstration of an SDN-enabled VCSEL-based Photonic System for Spectral/Spatial Connectivity in Disaggregated Optical Metro Networks

Ester Le Rouzic, *Orange Labs, USA*
Operationalizing Partially disaggregated Optical Networks: An Open Standards-driven Multi-vendor Demonstration

Nathan Ellsworth, *The University of Texas at Dallas, USA*
A Non-Proprietary Network Operations Platform for OpenROADM Environment

Abhinava Sadasivarao, *Infinera Corporation, USA*
Demonstration of Extensible Disaggregated NE Management based on a SONiC-compliant Software-Agent Optical OpenConfig/gNMI Telemetry Go Implementation

Carlos Manso, *CTTC, Spain*
Scalable for Cloud-native Transport SDNController Using GNPy and Machine Learning

Techniques for QoT Estimation

Jan Kundrát, *CESNET, Telecom Infra Project, Czechia*
GNPy & YANG: Open APIs for End-to-End Service Provisioning in Optical Networks

Dominic Schulz, *Fraunhofer Heinrich Hertz Institute, Germany*
All-Indoor Optical Customer Premises Equipment for Fixed Wireless Access

Patrick Yue, *The Hong Kong University of Science and Technology, Hong Kong*
High Precision Indoor Robot Localization Using VLC Enabled Smart Lighting

Liquiong Liu, *The Chinese University of Hong Kong, Hong Kong*
Li-poster: Real-time Non-line-of-sight Optical Camera Communication for Hand-held Smartphone Applications

Part 2: Monday, 7 June; 07:30 - 09:30 PDT (UTC-07:00)
Seongwook Choi, *LIPAC, South Korea*
A New FOWLP Platform for Hybrid Optical Packaging - Demonstration on 100Gbps Transceiver

Zi Hao Zhou, *South China University of Technology, China*
RSE-based Optical Camera Communication in Underwater Scenery with Bubble Degradation

Rodrigo Tessinari, *University of Bristol, USA*
Demonstration of a Dynamic QKD Network Control Using a QKD-Aware SDN Application Over a Programmable Hardware Encryptor

Joo Choo, *ADVA Optical Networking SE, Germany*
Demonstration of Software-defined Key Management for Quantum Key Distribution Network

Rossano Pinto, *UNICAMP, Brazil*
Demonstration of Machine-Intelligent Soft-Failure Localization Using SDN Telemetry

Huy Tran, *Nokia Bell Labs, USA*
Demonstration of ML-aided Impairment-aware L0 Path Computation in Fully Disaggregated Multi-vendor Optical Transport Networks

Behnam Shariati, *Fraunhofer Inst. Nachricht Henrich-Hertz, Germany*
Inter-Operator Machine Learning Model Trading over Acumos AI Federated Marketplace

Bob Lantz, *University of Arizona, USA*
SDN-controlled Dynamic Front-haul Provisioning, Emulated on Hardware and Virtual COSMOS Optical x-Haul Testbeds

Luca Valcarenghi, *Scuola Superiore Sant Anna di Pisa, Italy*

Experimental Demonstration of Scalable and Low Latency Crowd Management Enabled by 5G and AI in an Accelerated Edge Cloud

Filippo Cugini, *CNIT, Italy*

Demonstration of P4 Neural Network Switch

OFC Virtual Run and Walk

Anywhere, Everywhere

Grab your running shoes and head out for a walk or run in your hometown anytime during the week of OFC. Take a selfie, tag it with #werunOFC and share it with the rest of the OFC Twitter community @ofcconference.

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Lab Automation Hackathon

Sunday, 06 June, 11:00 – 13:00 PDT (UTC-7:00)

Organizers: Nicolas Fontaine, *Nokia Bell Labs, USA*; Binbin Guan, *Microsoft, USA*; Roland Ryf, *Nokia Bell Labs, USA*; Jochen Schroeder, *Chalmers University of Technology, Sweden*

Lab work is most efficient when data can be acquired in an automated way, especially when taking measurements over long durations. Automated acquisition avoids introducing human error and allows researchers to concentrate on the fun part of experimental work. Open source software in easy-to-learn languages such as Python provides just as much, or more features/interoperability for lab automation than alternative commercial software.

The hackathon format will consist of multiple interactive demos held in virtual breakout rooms in addition to a short introduction and a general Q/A. Researchers with 10+ years' experience in lab automation will show you the power of using Python to quickly get a lab experiment running and display the measurements in a web browser or GUI. Attendees will learn from companies that work in photonics and how they take advantage of Python to create easy interfaces to their software and hardware. Students will be able to show how they are developing new tools to complete their PhD.

**The OFC Hackathon will utilize the Remo platform, which may not be available to all attendees in all regions*.

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Technology Showcase: Creating Scalable and Flexible Future-Proof Networks with Programmable Optical System-on-Chip

Monday, 07 June, 03:30 – 04:00 PDT (UTC-7:00)

Speaker: Joost Verberk, *Director of Product Management*

Network traffic is growing exponentially but investments in infrastructure and operational costs cannot. This drives the need for an agile, scalable, and flexible solution that is not dependent on hardware-based innovation cycles. Software-based networking solutions that expose reconfigurability to the network orchestrator are a key part of this evolution. Programmable Optical System-on-Chips with open interfaces are a crucial, versatile building block of DevOps and the networks of the future.

Presented By: Photonics B.V.

EFFECT PHOTONICS

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Technology Showcase: Innovative Use of 400G ZR+ Reshapes Optical Network Economics

Monday, 07 June, 04:30 – 05:00 PDT (UTC-7:00)

Speaker: Jonathan Homa, *Senior Director of Solutions Marketing*

Contrary to some opinions, a distinct all-optical transport layer transiting CDC ROADMs will be with us for some time to come. However, the technology driving the wavelengths over this network will change. No longer will we need expensive embedded technologies. Instead, by using a new generation of 400G ZR+ pluggables in a CFP2 DCO form factor in an innovative way, we show how to transport 100GbE clients and growing 400GbE clients further at lower cost.

Presented By: Ribbon

ribbon

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OFC Career Zone: Career (Re) Start: Elevator Pitch, Resume Tips and Interview Best Practices (Part 1)

Monday, 07 June, 07:30 – 08:30 PDT (UTC-7:00)

An interactive webinar, where you will be given key insights to help you understand the relationship between your brand, elevator pitch, resume and interview answers. In addition to the classical discussions on resume tips, evaluator pitches and interviewing best practices, you will be provided with time to both work on the and get active feedback. Bring what you have.. or don't have… but come prepared to work!

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OSA Booth Tech Talk: Optics to Scale the Datacenter Network

Monday, 07 June, 11:00 – 11:30 PDT (UTC-7:00)

Ryohei Urata, Google, USA; Hong Liu, Google, USA

Over the past decade, datacenters have rapidly grown as an enabler of new applications and capabilities (cloud computing, machine learning, internet content streaming, internet search, social networking, etc.). As such, datacenter networks have become the singular force driving the business and technology development of corresponding fiber optic communications. In this presentation, we will review the evolution

of this network and corresponding optical interconnect technology over the past decade, as well as a roadmap and trends for the next 3 to 4 years.

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OSA Booth Tech Talk: Fiber Communication Networks - Telecom vs. Datacom

Monday, 07 June, 12:00 – 12:30 PDT (UTC-7:00)

Cedric F. Lam, Google, USA; Shuang Yin, Google, USA

This tech talk will provide an overview of fiber communication networks for telecom and datacom. We will compare and contrast the differences between these two application spaces in terms of key drivers, requirements, technology evolution and design philosophies. We try to shed some light on the directions for future R&D.

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OSA Booth Tech Talk: High Speed Semiconductor Lasers and Modulators for Data Communications

Monday, 07 June, 14:00 – 14:30 PDT (UTC-7:00)

John Bowers, Univ. of California at Santa Barbara, USA

Amplitude and phase modulation of light for transmission at 10, 40 and 100 Gbit/s and beyond are a critical problem for fiber-optic networks. We will review the basic concepts of high speed laser modulation and high speed optical modulators. The fundamental physics and design of modulators will be reviewed. The microwave characteristics of semiconductor lasers, important for high-speed digital and analog applications, are presented. Methods to increase the bandwidth are illustrated with examples from literature, along with results showing the current state of the art.

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Technology Showcase: Leveraging QSFP-DD and ZR/ZR+ in Networking Platforms

Monday, 07 June, 15:30 – 16:00 PDT (UTC-7:00)

Speaker: Steven Alleston, *Principal Product Manager*

Support for 400G services on fixed, high-capacity, high-density routing and switching platforms is quickly growing in availability. Still reeling from the unprecedented impact of a global pandemic to operator networks, and faced with the demands of emerging 5G, IoT, and low latency edge service, operators who relatively recently felt that 10GE would be the norm and 100GE the exception in their networks are increasingly envision applications for 400G. Fueled by the QSFP-DD formfactor that occupy the same physical faceplate space as a 100G QSPF28 interface, combined with the incredible flexibility and improved economics of coherent ZR and ZR+ pluggable technology, the adoption and application of 400G services appears to be outpacing the introduction of 100GE. Learn why network equipment suppliers like Juniper Network are broadly integrating QSFP-DD and ZR/ZR+ technologies across their portfolio and how they promise to bring new architectural efficiencies, opportunities, and savings to a variety of use cases and applications.

Presented By: Juniper Networks

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Technology Showcase: Cloud Metro – New Metro Architectures for 5G, IoT, and Low Latency Services

Monday, 07 June, 16:00 – 16:30 PDT (UTC-7:00)

Speaker: Amit Bhardwaj, *Senior Director Product Management*

New 5G, IoT, and low latency virtualized Edge services present a once-in-a-generation opportunity for communication service providers (CSPs) and large Enterprises. Leveraging a converged network, distributed services, and new capacity and architectures, operators can enable new applications that simply weren't possible before. Even better, network operators are the only ones who can deliver these innovations, carving out a more prominent (and profitable) role for themselves in the digital ecosystem. To do any of this though, they'll need to modernize the metro. Juniper Cloud Metro combines scalable IP service fabric, service intelligence, and automation to enable experience-first networking in the Cloud era.

In this session, you will learn what makes a Cloud Metro ideal for today's network challenges and opportunities to delivering experience-first networking.

Presented By: Juniper Networks

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Technology Showcase: Guaranteed Network Service Levels with Paragon Active Assurance

Monday, 07 June, 16:30 – 17:00 PDT (UTC-7:00)

Speaker: Cyril Doussau, *Product Marketing Director – Paragon WAN Automation*

Do you often wonder if network configuration changes have impacted your customers' service experience? Paragon Active Assurance inherently provides a uniform solution across all transport domains including wireless access, the branch office edge, SD-WAN, WAN, data centers and public clouds. It assures that on-demand services are always validated for high performance upon creation and throughout the entire service lifecycle. It forms the foundation of an automated solution for closed-loop assurance and self-healing across network domains. Paragon Active Assurance empowers your network engineers with visibility into the actual service quality your network is delivering from L2 to L7, allowing quick problem identification and mitigation before they can impact services and customer experience.

If your customers are the ones finding network problems or if you're seeking better ways to identify and mitigate network issues, please join us to learn:

What can be done about the biggest pain point in network management today.

Why Paragon Active Assurance delivers unprecedented visibility to quickly identify issues in even the most complex networks.

How to cost effectively and automatically deploy and leverage Active Assurance within your network.?

Presented By:

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Technology Showcase: Industry Trends and the Test Ramifications

Monday, 07 June, 17:30 – 18:00 PDT (UTC-7:00)

Speaker: Brig Asay, *Director of Strategic Planning, Network and Data Center Solutions*

In this showcase, Keysight will highlight technology evolution and how testing is changing to keep pace with your needs. As data centers continue to evolve, faster, lower-power underlying technologies are necessary to keep up with the demands. 100 GbE has given way to 200 and 400 GbE, with 800 GbE right around the corner. The constant upgrading of technology has serious test ramifications. Understanding the technologies that are coming and how testing can help you keep up with the demand for change is critical to your business needs.

Presented By: Keysight Technologies

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Technology Showcase: Optical Trends in Metro/Access Networks

Monday, 07 June, 18:00 – 18:30 PDT (UTC-7:00)

Speaker: Giorgio Cazzaniga, *Product Management Director*

While the capacity for each optical channel is scaling up in long haul and core networks reaching the 800G per channel, we're seeing the trend to push coherent technology in the access part of the network as an alternative to direct detection techniques. This in an overall more open network architecture where “optical white boxes” are becoming a reality.

This presentation will discuss the commoditization of coherent modules going from long haul to edge applications and if the time has come to take optical white boxes a step further.

Presented By: Jabil

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Technology Showcase: New Developments in Ultra High-Resolution Fiber Optic Testing

Monday, 07 June, 18:30 – 19:00 PDT (UTC-7:00)

Speaker: Wajih Daab, *Product Line Manager*

Join us to learn about new developments that expand the applications of high-resolution reflectometry for testing, diagnosing and certifying fiber optic links. Luna's Optical Backscatter Reflectometer (OBR) provides the spatial resolution, precision and speed not available with OTDRs, providing accurate distributed loss and location data with sampling resolution down to 10 microns, with no dead zone. A new portable OBR system extends the measurement length for convenient usage in data center and enterprise applications, bringing this valuable analysis tool out of the lab and into more field applications. Additionally, Luna expands its OBR offerings with new wavelength options to address high-precision testing and distributed loss analysis of 1060 nm systems.

Presented By: Luna Innovations

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OpenROADM – Now a Reality

Tuesday, 08 June, 05:30 – 06:30 PDT (UTC-7:00)

Session Description:

AT&T is well along in the deployment of the OpenROADM network. AT&T has deployed OpenROADM equipment from diverse suppliers in over a hundred offices in several metros. The OpenROADM equipment consists of ROADMs, transponders and switchponders operating at 100G, and 400G is completing certification shortly. AT&T will share the OpenROADM journey and learnings.

Moderator:

Steve Plote*, Optics Consulting Engineer (Retired), USA*

Steve Plote, most recently consulting as a Director of Business Development for Fiber Smart; is an Optics Consulting Engineer. He has worked with sales teams in the Americas as well as Channel Partners. Focusing on Network designs for the delivery of real time, next generation services for Video transport, Carrier Ethernet, Consumer Content Distribution, and Cloud Computing. He has had personal responsibility for the network engineering and support for the WEB2.0 and Content Service Providers in North America. Mr. Plote has more than 30 years of experience in Data Center Interconnect, Telecommunications and LAN switching and transmission solutions. Prior to Fiber Smart he was a Webscale Optics Consulting Engineer at Nokia. Prior to that he was Solutions Business Development and CSP Systems Engineering at BTI Systems and prior to that was Solutions Sales Director at Tellabs. He

has had many professional memberships and committee involvements including NANOG PC, OFC, MEF, IEEE, OSA, IEC and IETF.

Presenter:

John Paggi, *AT&T Labs, USA*

John Paggi is the Associate Vice President in AT&T Labs responsible for the architecture and design of the Packet Core, Optical, and Open Disaggregated Hardware solutions. John has several decades of experience with AT&T and has managed many network technology development programs including AT&T's Open ROADM program, flexible 400G long haul optical platform, three generations of IP/MPLS packet core platforms including the latest Open Dis-Aggregated Next Gen Core, and the provider edge platforms supporting AT&T's broadband, mobility, Internet, Ethernet, and VPN services. John has a MSEE from Purdue University.

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DARPA Project Update

Tuesday, 08 June, 07:00 – 08:00 PDT (UTC-7:00)

Session Description:

This session will provide an overview of relevant programs in DARPA's photonics portfolio, specifically highlighting PIPES, MOABB, LUMOS, and DODOS. The session will focus on programmatic goals and technical results from current DARPA performers.

Moderator:

Gordon Keeler, *DARPA, USA*

Dr. Gordon Keeler is a Program Manager in the Microsystems Technology Office at the Defense Advanced Research Projects Agency. His work focuses on accelerating the development of emerging photonics, electronics, and integration technologies to enable revolutionary optical microsystems. Prior to DARPA, he was a Principal Member of Technical Staff at Sandia National Laboratories and received a PhD in Applied Physics from Stanford University.

Presenters:

Gordon Keeler, *DARPA, USA*
Presentation Title: Integrated Photonics at DARPA

Vladimir Stojanovic, *University of California, Berkeley/Ayar Labs, USA*
Presentation Title: Optical I/O Journey: From Research Vision to Volume Production

Mike Watts, *Analog Photonics, USA*
Presentation Title: Optical Phased Array LiDAR

John Bowers, *University of California, Santa Barbara, USA*
Presentation Title: Silicon Photonic Integrated Circuits for Data Center Applications

Biographies:

Gordon Keeler, *DARPA, USA*
Presentation Title: Integrated Photonics at DARPA

Please see above biography.

Vladimir Stojanovic, *University of California, Berkeley/Ayar Labs, USA*
Presentation Title: Optical I/O Journey: From Research Vision to Volume Production

Vladimir Stojanovic is the Chief Architect of Ayar Labs. Prior to founding Ayar Labs, he led the team that designed the world's first processor to communicate using light. Vladimir is also a Professor of EECS at UC Berkeley, and was one of the key developers of the Rambus high-speed link technology. He holds a PhD from Stanford University.

Mike Watts, *Analog Photonics, USA*
Presentation Title: Optical Phased Array LiDAR

Michael R. Watts is the CEO of Analog Photonics in Boston MA where they are developing chip-scale Optical Phased Array LiDAR and Datacom Products. Mike also serves as CTO of AIM Photonics, the $600M public-private partnership to advance the state of US Manufacturing in Silicon Photonics. From 2010 to 2019, Dr. Watts was an Associate Professor (with Tenure) in the Department of Electrical Engineering and Computer Science (EECS) at the Massachusetts Institute of Technology. Prior to MIT, Mike was a Principle Member of Technical Staff at Sandia National Labs where he led their Silicon Photonic development effort from 2005-to-2010, focussing on ultralow power communications and sensing applications. Prior to Sandia, Mike was at MIT where he earned both his S.M. and PhD degrees in Electrical Engineering with theses in Silicon Photonics, developing the first polarization independent microphotonic circuit. From 1996-to-1999, Mike was a Member of Technical Staff at Draper's Fiber Optics Group, and in 1996 Mike earned his BSEE from Tufts University.

John Bowers, *University of California, Santa Barbara, USA*
Presentation Title: Silicon Photonic Integrated Circuits for Data Center Applications

John E. Bowers is Director of the Institute for Energy Efficiency and the Kavli Professor of Nanotechnology in the Departments of Electrical and Computer Engineering and Materials at the University of California at Santa Barbara. He received his master's and doctorate degrees from Stanford University. He previously worked for Bell Labs and Honeywell. He is a member of the National Academy of Engineering and a Fellow of the IEEE, OSA and American Physical Society. He is a recipient of the IEEE/LEOS William Streifer Award, the OSA Holonyak Award, the OSA/IEEE Tyndall Award and the IEEE Photonics award. He has published two books, eleven book chapters, 800 journal papers, 1000 conference papers and has received 70 patents.

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Standards Update on 5G Transport, PON, Latest OTN Technologies and More

Tuesday, 08 June, 07:00 – 08:00 PDT (UTC-7:00)

Session organized by International Telecommunication Union (ITU)

Session Description:

The international standards (ITU-T Recommendations) developed by Study Group 15 detail technical specifications giving shape to global communication infrastructure. The group's standards define technologies and architectures of optical transport networks enabling long-haul global information exchange; fibre- or copper-based access networks through which subscribers connect; and home networks connecting in-premises devices and interfacing with the outside world.

This includes the development of standards for the optical transport network, access network, home network and power utility network infrastructures, systems, equipment, optical fibres and cables and the related installation, maintenance, management, test, instrumentation and measurement techniques, and control plane technologies to enable the evolution toward intelligent transport networks, including the support of smart-grid applications.

This session presents hot topics from the latest development of international standards (ITU-T Recommendations) within ITU-T SG15, in particular, standardization work related to transport network support of IMT-2020/5G mobile, Higher Speed PON (Passive Optical Network) including the use of wavelength division multiplexing, latest OTN (Optical Transport Network) and other transport technologies that are applicable to IMT-2020/5G mobile radio access. This session also discusses interoperable optical interfaces at 200 Gbit/s and 400 Gbit/s per wavelength, including development of standardized interoperable interfaces using optical DP-16QAM modulation.

Moderator:

Hiroshi Ota, *Study Group Advisor, International Telecommunication Union (ITU), Switzerland*
Presentation Title: Standardization in ITU-T Study Group 15
Abstract: This presentation shows an overview of the work of ITU-T Study Group 15 (SG15) and introduces the speakers in this session from ITU-T SG15 on optical access networks, multi-vendor interoperable optical interface specifications and optical transport networks (OTN).

Hiroshi Ota is Advisor for ITU-T Study Group 15, which develops standards on networks, technologies and infrastructures for transport, access and home. He supports ITU-T SG15 by providing secretariat services as a staff member of ITU. He also coordinates the work on disaster relief and emergency communication within ITU and with related organizations.

Presenters:

Frank Effenberger*, Futurewei Technologies, USA*
Presentation Title: Optical Access in ITU-T: Recent Progress on Higher Speed Systems

Fabio Pittalà, *Huawei, Germany*
Presentation Title: Multi-Vendor Interoperable Optical Specifications in ITU-T

Tom Huber, *Nokia, USA*
Presentation Title: Recent Topics in Optical Transport Networks

Biographies:

Frank Effenberger*, Futurewei Technologies, USA*
Presentation Title: Optical Access in ITU-T: Recent Progress on Higher Speed Systems
Abstract: This presentation will review the workplan of Q2, introducing the new public "Flyers" as a guide. The highlight will be the completion of the Higher Speed PON standard series, which is the natural evolutionary step after XGS-PON.

Frank has researched fixed access systems for over 25 years at Bellcore, Quantum Bridge, and now at Futurewei, where he is the company Fellow responsible for this area. He has contributed to the design of many PON systems, the dominant access technology today, and to their standardization by holding

leadership roles at ITU-T, IEEE 802.3 and ETSI.

Fabio Pittalà, *Huawei, Germany*
Presentation Title: Multi-Vendor Interoperable Optical Specifications in ITU-T
Abstract: This presentation will review optical multi-vendor interoperable specifications currently under development in ITU-T SG15/Q6.

Fabio Pittalà received his Ph.D from the Technical University of Munich (TUM) and his M.Sc. in Telecommunication Engineering from the Technical University of Denmark (DTU). He is currently working as a Principal Engineer on high-speed coherent transmission systems at the European Research Institute of Huawei in Munich, Germany. He authors 30+ conference/journal papers and 10+ patents. He is also an active contributor to ITU-T SG15/Q6 mainly focusing on the specifications of interoperable coherent 100 Gbit/s, 200 Gbit/s and 400 Gbit/s optical interfaces for Recommendation ITU-T G.698.2.

Tom Huber, *Nokia, USA*
Presentation Title: Recent Topics in Optical Transport Networks
Abstract: This presentation will review recently completed standardization work in ITU-T WP3/15 related to Optical Transport Network (OTN). It also will include some discussion about new work regarding transport of beyond 400G clients.

Tom Huber is part of the optical standardization team at Nokia. He received his B.S. (Electrical and Computer Engineering) from the University of Notre Dame and M.S. (Computer System Engineering) from the Illinois Institute of Technology. He has been active in optical networking standardization for more than 20 years. He is associate rapporteur of ITU T Q11/15, Signal structures, interfaces and interworking for transport networks, and has been nominated as a vice chairman of ITU-T SG15, Networks, Technologies and Infrastructures for Transport, Access and Home. He also participates in the Optical Internetworking Forum (OIF) and IEEE 802.3.

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The 5th Generation Fixed Networks (F5G): New Use Cases and Technologies

Tuesday, 08 June, 07:00 – 08:00 PDT (UTC-7:00)

Session Description:

Fixed networks based on optical fiber form an essential foundation of modern digital communications. From access networks to core and data center networks, fiber is ubiquitous. Currently, there is an industry-wide effort to set a clear evolution path for fixed networks, similar to that seen in mobile networks with well-defined generations such as 3G, 4G, and 5G. The next generation of fixed networks is being regarded as the 5th generation of fixed networks (F5G). The European Telecommunications Standards Institute (ETSI) has recently established an Industry Specification Group (ISG) for F5G, aiming to define clear generational capabilities and features.

This workshop will bring together experts actively participating in this new F5G initiative, along with those deploying fiber networks and researching how fiber networks might evolve. Many new use cases will be discussed, from conventional telecoms, to emerging applications in vertical industries and in premises networks. Topics in scope of this workshop will also include new technologies for FTTH and LAN, transport networks, network slicing, autonomous operation and end-to-end quality of experience.

The workshop will serve as a forum to discuss what F5G is about and to influence the future evolution of optical fiber networks. We expect a lively exchange of views as F5G is such a new and rapidly moving

industry-wide initiative. It is hoped that new research and development activities will be stimulated by such discussions at OFC that will help define future generations of fixed networks in the 5G era and beyond.

Moderators:

Luca Pesando, *ETSI's F5G ISG, Italy*

Luca Pesando has more than twenty-five years of experience in Information and Communication Technologies with Telecom Italia. In the company, he is coordinator of standardization activities since 2006. At present Luca is chairman of ISG F5G of ETSI, and vice-chairman of ISG Experiential Network Intelligence (ENI). He is also co-chairman of WP1 in SG13 of ITU-T. In the past, Luca has covered leading roles in various standards initiatives in ESTI and independent Industry forums.

Xiang Liu, *Futurewei Technologies, USA*

Xiang Liu has over twenty years of experience in optical transport and access networks. He has authored over 350 publications and holds over 100 US patents. He has served as a General Co-Chair of OFC 2018, and is currently serving as a Deputy Editor of Optics Express and an Advisory Board member of NGOF. Dr. Liu is a Fellow of the OSA and the IEEE.

Presenters:

Luca Pesando, *ETSI's F5G ISG, Italy*
Presentation Title: Status Update on ETSI ISG-F5G

Philippe Chanclou, *Orange, France*
Presentation Title: New Applications and Use Cases Related to F5G

Frank Effenberger*, Fellow, Futurewei Technologies, USA*
Presentation Title: Progress on the Technical Work Items in F5G

Junjie Li, *China Telecom, China*
Presentation Title: Technical Progress Made by the Next-Generation Optical Network Forum (NGOF)

Biographies:

Philippe Chanclou, *Orange, France*
Presentation Title: New Applications and Use Cases Related to F5G

Philippe Chanclou received the Ph. D. and Habilitation degrees in 1999 and 2007. Since 2004, he joined Orange Labs where he was engaged in research on the next generation optical access networks. He is manager of Fixed Access Networks team which involves on FTTx topics for Home, Enterprise and Antenna.

Frank Effenberger*, Fellow, Futurewei Technologies, USA*
Presentation Title: Progress on the Technical Work Items in F5G
Abstract: This presentation will review the workplan of the ETSI F5G ISG, including topics like generation planning, use case development, technical landscape, architecture, quality of experience, end-to-end management, Industrial PON, proof of concept framework, and security.

Frank has researched fixed access systems for over 25 years at Bellcore, Quantum Bridge, and now at Futurewei, where he is the company Fellow responsible for this area. He has contributed to the design of many PON systems, the dominant access technology today, and to their standardization by holding

leadership roles at ITU-T, IEEE 802.3 and ETSI.

Junjie Li, *China Telecom, China*
Presentation Title: Technical Progress Made by the Next-Generation Optical Network Forum (NGOF)

Dr. Junjie Li has worked with China Telecom for more than 15 years in R&D and deployment of optical communication and networking technology. Currently he is Chief Expert of Optical Transport Network in China Telecom. Junjie got his PhD degree from Tsinghua University, Beijing. Junjie served as China Telecom representative in OIF (Optical Internetworking Forum) from 2008 and was OIF BoD member from 2015 to 2017 and OIF NetOp (Net Operator) WG Chair from 2017 till now. Dr. Li served as a TPC member of OECC2016, OFC2018, OFC2019 and OFC2020. Junjie is one of co-founders of NGOF (Next Generation Optical transport network Forum) and served as the Executive Director of NGOF from 2017.

Luca Pesando, *ETSI's F5G ISG, Italy*
Presentation Title: Status Update on ETSI ISG-F5G

Biography above

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OSA Technical Group Event

Tuesday, 08 June, 07:00 – 08:00 PDT (UTC-7:00)

Nonlinear Signal Processing Coming of Age: From Nice Lab Demonstrations to Network Components

The OSA Fiber Optics Technology and Applications Technical Group invites you to join them for this special event led by Prof. Periklis Petropoulos and Dr. Kyle Bottrill of the Optoelectronics Research Centre, University of Southampton, and moderated by Prof. Peter Andrekson of Chalmers Tekniska Högskola.

Optical nonlinear effects have long been studied for their potential for the processing of optical data signals. Their benefits, when compared to the alternative of O/E conversion and electronic processing, are generally outweighed by complex and bulky configurations that require customization and expert training for their operation. Using the example of wavelength conversion, which represents a fundamental signal processing operation with the potential to simplify network management, Prof. Petropoulous and Dr. Bottrill will discuss the steps that have been necessary to transform a lab-based experimental configuration involving several independently controlled active components into a turn-key black-box instrument. The event will include a 20-minute introductory talk, followed by an online demonstration of the technology and an open discussion moderated by Prof. Andrekson where members of the audience who have been involved in start-up activities can share their views and experiences.

Moderator:

Peter Andrekson, *Chalmers Tekniska Högskola, Sweden*

Panelists:

Periklis Petropoulos, *University of Southampton, UK*
Kyle Bottrill, *University of Southampton, UK*

Organized by: OSA Fiber Optics Technology and Applications Technical Group

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Plenary Speakers Live Q&A;

Tuesday, 08 June, 08:00 – 11:00 PDT (UTC-7:00)

Immediately following the plenary program, each speaker will participate in a live Q&A discussion on their groundbreaking initiatives -- Yiqun Cai, Alibaba Group, China; Young-Kai Chen, Microsystems Technology Office, DARPA, USA; and Nancy Shemwell, Trilogy Networks, USA. They will join OFC General Chairs Jun-ichi Kani, Po Dong and Chongjin Xie, OFC Program Chair Ramon Casellas, OSA Senior Industry Advisor Tom Hausken and OSA Science Advisor C. Randy Giles and registrants for in-depth talks on the evolution of networking, photonics and AI and deployment of edge cloud for rural areas.

Order of Speakers:

Yiqun Cai, *Alibaba Group, China*
Young-Kai Chen, *DARPA, USA*
Nancy Shemwell, *Trilogy Networks, USA*

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Technology Showcase: Scalable Implementation of Next Generation Security Technologies for Enterprise and Access Networks

Tuesday, 08 June, 10:00 – 10:30 PDT (UTC-7:00)

Speaker: Awanish Verma, *Principal Architect & Director Technical Marketing*

Xilinx's 16nm FPGAs and SoCs and 7nm Versal™ ACAPs offer multiple architectural components in the form of hardened blocks and soft IP, which make them ideal for designing next-generation security appliances. These IPs include high-speed SerDes and multirate interface IP, such as hardened MAC, PCIe® interfaces, and memory controllers. Xilinx devices also offer the latest state-of-the-art memory architecture with soft search IPs for flow classification, making them best suited for network security and firewall applications.

Presented By: Xilinx, Inc.

XILINX®

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Technology Showcase: XR Optics – Applications and Network Benefits

Tuesday, 08 June, 10:30 – 11:00 PDT (UTC-7:00)

Speaker: Dave Welch, *Chief Innovation Officer*

This session will explore the transformative XR optics transmission technology and the benefits it provides to network operators. Included will be a discussion on point-to-point use cases, point-to-multipoint use cases, and multi-generational upgrades as well as management and control. The session will explore the use of XR optics in numerous network applications such as 5G, PON, and metro/regional transport.

Presented By: Infinera

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Panel I: State of the Industry

Tuesday, 08 June, 10:30 – 12:00 PDT (UTC-7:00)

Speaker: Tim Doiron, Infinera, USA

Moderator: Tim Doiron, Infinera, USA

Panel Description:

The State of the Industry is one of the most highly anticipated Market Watch panels at OFC. Each year, a mix of industry and financial analysts present their unique view on the current state of the optical market, discussing areas that encompass components, subsystems, and system manufacturers as well as market influences and drivers. In doing so, the session will cover factors that influenced the past year and describe trends that are expected to define the future. By the conclusion of this panel presentation and Q&A, the audience will have gathered a deeper understanding of the industry with valuable market data points that will help them achieve a better appreciation for the state of the industry.

Speakers:

Alex Henderson, *Needham & Company, USA*

George Notter*, Jefferies, USA*

Vlad Kozlov, *LightCounting Market Research, USA*

Jimmy Yu, *Dell'Oro, USA*

Andrew Schmitt, *Cignal Ai, USA*

Biographies:

Tim Doiron, *Infinera, USA*

Tim Doiron is Sr. Director, Solution Marketing at Infinera, where he focuses on innovative networking solutions that include open optical networking, disaggregated routing, next-generation mobile transport, and intelligent software automation. In this role, Tim leads the global marketing team responsible for go-to-market strategies and communications programs. Built upon open, disaggregated, and programmable

network innovation, Infinera's solutions enable network operators to increase networking capacity and visibility while accelerating service velocity and simplifying operations. Tim brings more than 25 years of networking and telecommunications experience across business and technical organizations, including roles in marketing, product management, and engineering in executive and managerial roles at vendor and service provider companies, including Coriant, Tellabs, ARRIS, Cadant, Ericsson, and AT&T Mobility. Tim is a frequent speaker at industry conferences and has authored numerous articles. He holds an MBA from Webster University, an M.S. in electrical engineering from Virginia Polytechnic Institute and State University, and a B.S. in electrical engineering from Southern Illinois University. He also holds eight patents and is a member of IEEE and the Optical Society (OSA).

Alex Henderson, *Needham & Company, USA*

Alex Henderson joined Needham & Company in 2012, where he covers the networking and security technology industries. Prior to joining Needham, Alex worked at Citigroup and Prudential Securities, where he worked as a senior research analyst and served as Prudential's director of technology research. He has been a senior technology analyst for over 33 years and ranked in the Institutional Investor All-Star Poll 17 times with #1 rank 11 times. He has also been elected to the Institutional Investor Hall of Fame. Alex was ranked #1 in the 2013 FT/StarMine Analyst Awards for stock picking in the Communications Equipment category. He started his career as a consultant at The Boston Consulting Group. He received a B.A. in Physics and Applied Mathematics from Bard College and an MBA from Vanderbilt University.

Vlad Kozlov, *LightCounting Market Research, USA*

Vladimir Kozlov is the founder and CEO of LightCounting, an optical communications market research company. LightCounting was established in 2004 with an objective of providing in-depth coverage of market and technologies for high speed optoelectronic interfaces employed in communications. By now, the company employs a team of industry experts and offers comprehensive coverage of optical communications supply chain. Dr. Kozlov has more than 20 years of experience in optoelectronics, optical communications and market research. Dr. Kozlov held market analyst, product development and research staff positions at RHK Inc., Lucent Technologies and Princeton University. Dr. Kozlov holds several US patents and has numerous publications in the area of optoelectronics. He received M. Sc. at Moscow State University in Russia and Ph. D in Physics at Brown University in the United States.

George Notter*, Jefferies, USA*

George C. Notter is a Managing Director and Equity Research Analyst covering the Communications Infrastructure Sector. Mr. Notter has 25 years of equity research experience exclusively in the Communications Infrastructure Sector. He joined Jefferies in May 2004. Prior to Jefferies, Mr. Notter served as a Communications Equipment Equity Research Analyst at Deutsche Bank for four years. Previously, he performed in the same role for Dain Rauscher Wessels, now a part of RBC Capital Markets. Mr. Notter received a MS in Finance from the University of Wisconsin (1995). While pursuing his Masters degree, he managed an investment portfolio for the renowned Applied Security Analysis Program at Wisconsin. Notter also holds a BS degree in Finance from the University of Wisconsin (1993). He was ranked #3 in the 2019 and 2020 Institutional Investor All-American Research poll and Runner-Up in the 2015, 2016, 2017, and 2018 polls. In 2018, Notter was rated one of the Top 100 Wall Street Analysts for stock-picking performance (TipRanks). In 2019, he won the Starmine award as the #1 Stock Picker in the Communications Equipment sector. Notter lives in the Bay Area with his wife and two kids.

Andrew Schmitt, *Cignal Ai, USA*

Andrew Schmitt is the founder and directing analyst at Cignal AI, where he leads quantitative and qualitative research on the networking market's entire supply chain. He is quoted and consulted by industry publications such as Lightwave and LightReading and is a member of the OFC Planning Committee. Mr. Schmitt is invited to speak at events including OFC, ECOC, FOE, and IIR conferences. He also provides consulting services to startups, carriers, vendors, and the investment community on developing business opportunities and market strategy.

Jimmy Yu, *Dell'Oro, USA*

Jimmy Yu covers Optical Transport and Microwave Transmission market research at Dell'Oro Group, and since joining Dell'Oro Group in 2001 has become a recognized authority on the Optical Transport market. Prior to his time at Dell'Oro Group, Jimmy worked in product development at Northrop Grumman, management consulting at Deloitte Consulting, and strategic product marketing at Spansion. Mr. Yu received a B.S. degree in Mechanical Engineering from University of California, Davis and an M.B.A. from the University of Michigan.

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Electrical Data Rates Keep Pushing Forward; An OIF Update

Tuesday, 08 June, 11:00 – 12:00 PDT (UTC-7:00)

Session organized by Optical Internetworking Forum (OIF)

Session Description:

A panel of industry experts and OIF members will provide an update on OIF's CEI-112G and CEI-224G development work including discussion and debate of 224G modulations.

Moderator:

Nathan Tracy, *TE Connectivity/OIF, USA*

Nathan Tracy currently serves as OIF's VP of Marketing and member of the board of directors. During the past ten years he has also served OIF as president, technical committee chair and technical committee vice chair. As a technologist on the system architecture team and manager of industry standards for the Data and Devices business unit at TE Connectivity (TE), Nathan is responsible for driving standards activities and working with key customers to enable new system architectures. Nathan has more than 30 years of experience in technology development, marketing and business development for TE in areas including RF/microwave, and high-speed signaling technology for the networking, telecom, wireless, automotive and defense markets. Nathan is also an active member of other industry standards and associations. Currently he serves the Ethernet Alliance as a member of the board, and he is a regular attendee and contributor to IEEE 802.3 and COBO. Additionally, he is active in a number of industry MSAs and forums where he has held leadership roles. Nathan earned his Bachelor of Science Electrical Engineering Technology degree from the University of Massachusetts, Dartmouth.

Presenters:

Dave Stauffer, *Kandou Bus/OIF, Switzerland*
Presentation Title: OIF Common Electrical I/O – History and Future

Gary Nichol, *Cisco Systems/OIF, USA*
Presentation Title: Considerations for 112 Gbps and 224 Gbps Applications - A System Vendor Perspective

Nathan Tracy, *TE Connectivity/OIF, USA*
Presentation Title: Channel Considerations for 112 Gbps and 224 Gbps Applications

Cathy Liu, *Broadcom, USA*
Presentation Title: CEI-112G-MR/LR-PAM4 and CEI-224G Outlooks

Mike Li, *Intel, USA*
Presentation Title: CEI-112G-XSR/VSR-PAM4 Updates and CEI-224G Outlooks

Thananya Baldwin, *Keysight Technologies, USA*
Presentation Title: Test and Measurement Challenges for the Higher Rates

Biographies:

Thananya Baldwin, *Keysight Technologies, USA*
Presentation Title: Test and Measurement Challenges for the Higher Rates
Abstract: With higher speeds, there is a convergence of testing for "what the bit looks like" the same time as "what it carries". Striping data across multiple lanes pose a challenge to traditional, per channel, analog test equipment. To better understand potential issues, a best-in-class test solution must have visibility into both "what the bit looks like" as well as "what it carries".

Thananya Baldwin is an accomplished engineering leader and recognized thought leader for High-Speed Ethernet (HSE) test products and technologies. She is currently vice president of strategic programs with Keysight's Networking Labs. In this role, she has led ground-breaking programs enabling introduction of the first 25GE, 40GE, 50GE, 100GE and 400GE test systems. While running these leading- edge programs, Thananya actively participates in the IEEE 802.3 Higher Speed Ethernet standard bodies and Optical Internetworking Forum (OIF) projects. Prior to Keysight, she was a technology innovator and evangelist at Ixia, acquired by Keysight in 2018. Thananya holds a Bachelor's of Science in Engineering and a Master's of Business Administration. She is an avid world traveler and SCUBA diving enthusiast.

Mike Li, *Intel, USA*
Presentation Title: CEI-112G-XSR/VSR-PAM4 Updates and CEI-224G Outlooks
Abstract: Will review the latest on CEI-112G-VSR-PAM4 and CEI-112G-XSR-PAM4 specifications and provide 224 Gbps investigation results on silicon, channel, and link system for various reaches, from XSR to MR, LR, via simulations and measurements.

Dr. Peng (Mike) Li is an Intel Fellow and the technologist for high-speed I/O and interconnects at Intel Corporation. He serves as Intel's technical expert and adviser in high-speed I/O and link technology; standards; SerDes architecture; electrical and optical signaling and interconnects; silicon photonics integration; optical field-programmable gate arrays (OFPGAs); and high-speed simulation, debug and test for jitter, noise, signaling and power integrity, from deign validation, to high-volume manufacturing (HVM). Li joined Intel in 2015 with the acquisition of Altera Corp., where he had held a similar role since 2012. Before joining Altera in 2007, Li spent nearly a decade at Wavecrest Corp., culminating in his seven-year tenure as chief technology officer (CTO). He began his career in 1991 as a post-doctorate researcher at the Space Sciences Laboratory at the University of California, Berkeley. Li earned a bachelor's degree in space physics from the University of Science and Technology of China in Hefei, China; a master's degree in physics and a master's degree in electrical and computer engineering, both from the University of Alabama in Huntsville (UAH); and a Ph.D. in physics, also from UAH. Li was named an IEEE Fellow in 2012, an Intel Fellow in 2015, and Engineer of the year (2018, Designcon). He has been elected as an

affiliated professor at the Department of Electrical Engineering, University of Washington, Seattle, since 2010.

Cathy Liu, *Broadcom, USA*
Presentation Title: CEI-112G-MR/LR-PAM4 and CEI-224G Outlooks
Abstract: Will provide status updates on CEI-112G-MR and CEI-112G-LR interfaces and explore modulation options and system performance at next speed node of 224Gb/s over electrical interfaces including die-die/OE, chip-module, chip-chip and copper cables.

Cathy Ye Liu, distinguished Engineer and director, currently heads up Broadcom SerDes architecture and modeling group. Previously she worked as R&D director and distinguished engineer in Avago/LSI which acquired Broadcom in 2016. Since 2002, she has been working on high speed transceiver solutions. Previously she has developed read channel and mobile digital TV receiver solutions. Her technical interests are signal processing, FEC, and modeling in high-speed optical and electrical transceiver solutions. She has published many journal and conference papers and holds 20+ US patents. Cathy has demonstrated her leadership roles in industry standard bodies and forums. Cathy served as a member of the board director of Optical Internetworking Forum (OIF) from 2017-2020. Currently she serves as a member of the board of advisors for the department of Electrical & Computer Engineering (ECE) of University of California at Davis, a member of Signal Integrity Journal editorial advisory board, and the co-chair of the DesignCon technical track of high speed signal processing, equalization and coding.

Gary Nichol, *Cisco Systems/OIF, USA*
Presentation Title: Considerations for 112 Gbps and 224 Gbps Applications - A System Vendor Perspective
Abstract: This talk will consider the challenges and system needs for next generation 224Gb/s electrical interfaces. The key message will be “Power is Everything”.

Gary is a Principal Engineer working in the Transceiver Module Group (TMG) at Cisco Systems. He is responsible for defining strategy and technology for high-speed interconnect across Cisco’s routing and switching platforms. Gary also represents Cisco at various industry standards organizations and was an active contributor in the development of 25G, 40G, 100G and 400G standards at the IEEE, OIF and ITU. He was a clause editor for the IEEE 802.3cd project (50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet) and chief editor for the IEEE 802.3cu project (100 Gb/s and 400 Gb/s over SMF at 100 Gb/s per Wavelength). Gary was also a member of the core team responsible for defining the common management interface specification (CMIS), which is widely used throughout the industry for next generation pluggable optical modules. Gary currently serves as Treasurer/Secretary for OIF. Prior to joining Cisco Gary spent 10 years at Nortel Networks in Ottawa, working in various R&D roles in the development of OC-3, OC-12 and OC48 optical transport products. Gary holds a B.Sc. in Electrical Engineering from the University of Manchester (UK).

Dave Stauffer, *Kandou Bus/OIF, Switzerland*
Presentation Title: OIF Common Electrical I/O – History and Future
Abstract: Will cover the (standard) historical timeline, 112G taxonomy, and 224G introduction.

Dr. Stauffer has expertise in logic design and architecture for High Speed Serdes and DDR memory interface applications, both in his current position as Director of Chip Architecture at Kandou Bus, and in his previous position as a Senior Technical Staff Member at IBM. He is a contributor to serial link standards (OIF Common Electrical I/O (CEI), INCITS T11 Fibre Channel, Universal Serial Bus 4, JEDEC JESD247), and is the current Chair of the OIF Physical and Link Layer Working Group. Publications include “High Speed Serdes Devices and Applications”, Springer, 2008.

Nathan Tracy, *TE Connectivity/OIF, USA*
Presentation Title: Channel Considerations for 112 Gbps and 224 Gbps Applications
Abstract: A review of 112G channel scenarios will be discussed and then a look at possible channels for 224 Gbps will be discussed.

Please see biography above.

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OSA Booth Tech Talk: 50G-PON: The Latest ITU PON System

Tuesday, 08 June, 11:00 – 11:30 PDT (UTC-7:00)

Yuanqiu Luo, Futurewei, USA

This talk introduces passive optical network (PON) technologies and applications in the optical broadband access areas. It focuses on the latest ITU PON system, 50G-PON. The 50G-PON system is specified by the ITU G.9804 series of recommendations. This talk reviews major features of 50G-PON in both physical and protocol layers. Future research and development work are discussed to drive this solution.

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OFC Career Zone: Career (Re) Start: Elevator Pitch, Resume Tips and Interview Best Practices (Part 2)

Tuesday, 08 June, 11:30 – 13:00 PDT (UTC-7:00)

We are building off of Part 1 today. We will start with your resume and current/former vocation as a basis of the discussion. We will then address upskilling and the need to remain current in your field. Aligning your passion, skills and strengths to the current job landscape as well as identifying transferable skill sets that allow you to expand your job search. You will walk away with tools that allow you to evaluate your skill set, network and next steps as you transition to your next opportunity.

Bring your resume and a list of your current skill sets, and come ready to actively participate as we help you explore potential opportunities. All levels of experience welcomed to participate.

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Data Center Summit, Keynote: Gaya Nagarajan, Director, Network Engineering, Facebook, USA

Tuesday, 08 June, 11:45 – 12:15 PDT (UTC-7:00)

Speaker: Loukas Paraschis, Infinera, USA

Moderator: Loukas Paraschis, Infinera, USA

Speakers: Gaya Nagarajan*, Director, Network Engineering, Network Infrastructure, Facebook, USA*

Biographies: Gaya Nagarajan*, Director, Network Engineering, Network Infrastructure, Facebook, USA*

Gaya Nagarajan is an Engineering Director at Facebook. In this role, he responsible for Engineering and Planning infrastructure of the Facebook Backbone Network. Before Facebook, he was at Brocade, where he focused on building products catering to various large service provider customers. Gaya has more than 10 years of experience in networking after completing his masters at University of Kansas. Outside of the network world, he has a passion for sports and enjoys playing cricket, golf and racquetball.

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Educational Wordwide Lab Tour: Part One

Tuesday, 08 June, 12:00 – 13:30 PDT (UTC-7:00)

Organizers: Nicolas Fontaine*, Nokia Bell Labs, USA;* Michela Moreolo*, Centre Tecnològic de Telecomunicacions de Catalunya, Spain;* Chigo Okonkwo, *Technische Universiteit Eindhoven, Netherlands;* Georg Rademacher, *NICT, Japan*

Have you ever wondered what the inside of a research lab looks like and how the scientists, researchers and engineers conduct experiments?

Come join the virtual lab tour event! Eight scientists from around the world will provide a tour of their lab through prerecorded video showing off their equipment, describing their experimental setup and automation techniques, and showing how they fabricate fibers and photonic devices. The demonstrations will be followed by an interactive Q/A session.

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OSA Booth Tech Talk: Lessons Learned in Data Transmission and Processing in Optical Communication Systems

Tuesday, 08 June, 12:00 – 12:30 PDT (UTC-7:00)

The transmission and processing of data in optical communication systems has experienced astounding success and growth. Although there have been many technological advances, there were also many lessons learned as far as what issues can derail the deployment of certain technologies. This presentation will describe some R&D perspectives in terms of concerns and hurdles, with highlights involving capacity growth using multiplexing schemes, performance and functionality enhancement through signal processing, and directionally and bandwidth in free-space links.

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Panel I: What is next for Inter Data Center Interconnects (DCIs)?

Tuesday, 08 June, 12:15 – 13:45 PDT (UTC-7:00)

Speaker: Loukas Paraschis, Infinera, USA

Moderator: Loukas Paraschis, *Infinera, USA*

Panel Description:

The networks interconnecting datacenters, commonly referred to as DCI, has grown more than any other transport infrastructure in the last decade, and is projected to grow by several orders of magnitude in the coming years. Consequently, the economics associated with this growth have motivated the development

of 1) dedicated DCI networks which account for some of the most spectrally efficient fiber deployments globally, and 2) a new class of purpose-built DCI transport systems. DCIs has also pioneered in optical transport the adoption of software innovations in automation, programmability, management abstraction, and control-plane disaggregation, as well as the introduction of the associated open transport architectures. This panel of industry leaders will discuss the extent to which these innovations have been successful in current and future DCI networks, and debate the important emerging innovations.

Speakers:

Andreas Bechtolsheim, *Arista Networks, USA*
Presentation Title: To be determined

Chongjin Xie, *Alibaba Group, USA*
Presentation Title: To be determined

Matthew Mitchell, *Facebook Optical Network Engineering, USA*
Presentation Title: To be determined

Yawei Yin, *Microsoft, USA*
Presentation Title: To be determined

Michael Strunz-Kroll, *euNetworks, Germany*
Presentation Title: OpenDCI from the Ground Up: Scaling Disaggregated Bandwidth Infrastructure Solutions in the European Market

Biographies:

Andreas Bechtolsheim, *Arista Networks, USA*
Presentation Title: To be determined

Andreas “Andy” Bechtolsheim is Chairman, Chief Development Officer and Co-Founder of Arista Networks, a leading vendor of cloud networking solutions. Previously, Andy was a Co-Founder and Chief System Architect at Sun Microsystems, responsible for next generation server, storage, and network architectures. As a private venture investor, Andy has been involved in the funding of numerous companies including Google, VMware, Mellanox, and Brocade. He has served on the Board of Directors of over 25 companies, the majority of which went public or were acquired. Andy earned a M.S. in Computer Engineering from Carnegie Mellon University in 1976. He was a doctoral student in Computer Engineering at Stanford University from 1977 to 1982. He has been honored with a Fulbright scholarship, a Studienstiftung scholarship, the Stanford Entrepreneur Company of the year award, the Smithsonian Leadership Award for Innovation, and he is a member of the National Academy of Engineering.

Michael Strunz-Kroll, *euNetworks, Germany*
Presentation Title: OpenDCI from the Ground Up: Scaling Disaggregated Bandwidth Infrastructure Solutions in the European Market
Abstract: Staying successful in the highly segmented European market with newcomer DC operators, traditional telco’s, ISP’s, various sized established players and big content providers means innovation needs to happen across many layers. This presentation will share an insight from a network operator perspective into the latest trends around increasing network density and diversity, deployment of the newest fibre type technologies as well as offering disaggregated open optical solutions and delivering process automation.

Michael Strunz-Kroll is Head of Architecture and Engineering at euNetworks, responsible for the strategic technology and platform decisions, its introduction into operations and life-cycle management. He joined euNetworks in 2011. Michael holds an engineering diploma in telecommunications and is working in the alternative network operator industry for now 20 years. He started his career in IBM and worked in scientific networks when working for the computing center of Berlin Free University. He had various senior technical and management roles when working in network operators like interoute, lambdanet and teragate. Michael had leading roles during past M&A activities of euNetworks making sure a fast frictionless integration maintained the lean operations approach of the company. Michael is directly involved in the design of high scalable solutions in the big content and hyperscale segment.

Matthew Mitchell, *Facebook Optical Network Engineering, USA*
Presentation Title: To be determined

Matthew Mitchell manages the Facebook Engineering team responsible for optical transport infrastructure outside of datacenters covering the metro, long haul, and subsea space. Prior to joining Facebook, he served as VP of Optical Systems Architecture at Infinera Corporation, and held positions at Corvis Corporation and Lucent Bell Laboratories. He earned his MS and Ph.D. degrees in Electrical Engineering from Princeton University in 1995 and 1998, respectively. He has co-authored over 30 peer-reviewed publications and holds 28 patents in the area of optical transmission and nonlinear optics.

Loukas Paraschis, *Infinera, USA*

Loukas Paraschis is senior director of cloud transport system engineering for Internet and content providers at Infinera. From 2007-2015, Loukas was cisco's senior technology architect for wireline transport in global service provider, and from 2000-2006 technical leader in cisco optical networking and routing. He has (co)authored more than 100 peer-reviewed publications, invited and tutorial presentations, book chapters, and 5 patents, has served in many IEEE and OSA leadership positions, including the OFC and JOCN steering committees, as JOCN associated editor, IEEE Photonics Society Distinguished Lecturer (2009), and is an OSA Fellow (2011). Loukas graduated from Stanford University (PhD 1999, MS 1998) where he worked at the Information Systems and Networking Research laboratories. He was born in Athens, Greece, where he completed his undergraduate studies.

Yawei Yin, *Microsoft, USA*
Presentation Title: To be determined

Yawei Yin is a principal network developer manager at the WAN Optical Networking team of Microsoft Azure. His focus includes the design, deploy, operation and automation of the metro, long-haul and subsea optical transport networks for Microsoft Azure. Prior to Microsoft, he worked at Alibaba Group as a staff engineer who was leading the design and automation of the optical transport network. Yawei Yin has also been active in optical networking research community for more than 10 years. He has (co)authored more than 80 peer-reviewed publications, invited presentations, book chapters etc., and is a (co)inventor of 6 patents. He has served the academic community in many different positions, including the technical program committee of IEEE/OSA OFC, IEEE GLOBECOM and ICC conferences, the editor and reviewer of many different academic journals etc. Yawei Yin earned his Ph.D degree in Electrical Engineering with a focus on optical networking from Beijing University of Posts and Telecommunications.

Chongjin Xie, *Alibaba Group, USA*
Presentation Title: To be determined

Chongjin Xie is a senior director in Alibaba Group, leading an optical network team working on datacenter optical interconnect. Prior to joining Alibaba in 2014, Dr. Xie was a Distinguished Member of Technical

Staff at Bell Labs, Alcatel-Lucent, doing research on optical communications. He was a post-doctor at Chalmers University of Technology from 1999 to 2001, and received his M.Sc. and Ph.D. degrees from Beijing University of Posts & Telecommunications in 1996 and 1999, respectively. Dr. Xie has published one book, 4 book chapters and over 200 papers. He is a Fellow of OSA and a senior member of IEEE.

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OFC Media/Analyst Panel: Data Center Optics are Heading Toward Co-packaged Optics: Why, How and When?

Tuesday, 08 June, 12:30 – 13:30 PDT (UTC-7:00)

Speaker: Lisa Huff, *Omdia, USA*

This panel of esteemed industry experts will discuss the need for co-packaged optics (CPO) inside the data center. The path to CPO commercialization is fraught with risk. An entire ecosystem must be developed to support the transition from pluggable modules. Our panel consists of specialists who come from different parts of this potential ecosystem to deliberate CPO's merits, its potential pitfalls, how and perhaps when it can be successful. Please join us for our open discussion.

Moderator: Lisa Huff, *Omdia, USA*

Panelists:
Andreas Bechtolsheim, *Arista Networks, USA*
Robert Blum, *Intel, USA*
Mark Filer, *Microsoft & OIF, USA*
Katarzyna Lawniczuk, *Bright Photonics, Netherlands*

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Tribute to Mitchell Fields

Tuesday, 08 June, 14:00 – 14:15 PDT (UTC-7:00)

Dr. Mitchell "Mitch" Fields (1969-2019), a Yale educated optical communications technologist and business executive, was admired by all who knew him for his earnest belief in the good in people and his relentless optimism. The industry lost Mitch in April 2019 from glioblastoma after participating in multiple advanced treatment regimens - many of which he shared during a OFC presentation just a month before. Fields was pivotal in the technology collaboration between IBM and Agilent on the optically interconnected PERCS program in 2007, one of the earliest commercial examples of co-packaging ASICs and optics. As an executive at Avago and Broadcom's optical communications group, he continued to lead the industry in development and adoption of leading edge III-V and transceiver solutions. This session will be a short tribute to honor a community member whose short life impacted so many.

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Panel II: Inside the Data Center

Tuesday, 08 June, 14:15 – 15:45 PDT (UTC-7:00)

Speaker: Hideki Isono, Fujitsu Optical Components, Japan

Moderator: Hideki Isono, Fujitsu Optical Components, JapanPanel Description:Global Datacenter IP traffic, growing rapidly at a 26 percent year over year growth rate, is to become 4.8 Zettabytes in 2022, according to Cisco Visual Networking Index 2019. To meet this huge capacity demand,...

View Full Event Details

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Panel III: Terabit WDM Channels: Beyond 100GBaud Operation

Tuesday, 08 June, 14:30 – 16:00 PDT (UTC-7:00)

Speaker: Andrew Schmitt, Cignal AI, USA

Moderator: Andrew Schmitt, *Cignal AI, USA*

Panel Description:

Network operators are deploying the latest 5th generation of coherent optics capable of 800G operation. There are many engineering and commercial challenges involved with building even faster single-carrier systems capable of 1 Terabit operation and beyond. This panel will examine potential DSP, optical, and packaging technologies to make these systems a reality. It will also consider the business case for developing these solutions vs. using lower performance optics as the Shannon limit is reached.

Speakers:

Tom Williams, *Acacia (now part of Cisco Systems), USA*
Presentation Title: Silicon Photonics for Next-Generation Coherent Interconnects

Martin Zirngibl, *II-VI Incorporated, USA*
Presentation Title: Enabling Optics & Integration Technologies for Terabit Transmission

Karthikeyan Balasubramanian, *Microsoft, USA*
Presentation Title: Higher Baud Rate - Benefits and Barriers

Radha Nagarajan, *Inphi, USA*
Presentation Title: Technology Options to Enable 800Gb/1.6Tb Coherent Modules

Robert Maher, *Infinera, USA*
Presentation Title: Next Generation Vertically Optimized Digital Coherent MODEMs

Biographies:

Andrew Schmitt, *Cignal AI, USA*

Andrew Schmitt is the founder and directing analyst at Cignal AI, where he leads quantitative and qualitative research on the networking market's entire supply chain. He is quoted and consulted by industry publications such as Lightwave and LightReading and is a member of the OFC Planning Committee. Mr. Schmitt is invited to speak at events including OFC, ECOC, FOE, and IIR conferences. He also provides consulting services to startups, carriers, vendors, and the investment community on developing business opportunities and market strategy.

Karthikeyan Balasubramanian, *Microsoft, USA*
Presentation Title: Higher Baud Rate - Benefits and Barriers
Abstract: From network operator's view point, going for higher baud rate has clear economic ($/bit/sec), power (fewer transponders) and operational benefits (fewer transponder and line system hardware to manage). Spectrum efficiency (which usually translates to total fiber capacity) exhibits a plateauing effect with higher baud rates - actual SE gain % while going to bauds greater than 100 Gbaud remains to be demonstrated. On the other hand, not all traffic demands are born equal. Elephant and mice flows coexists in our network. We need to consider the additional problem of wavelength planning and routing in mesh networks, where smaller traffic demand can be handled by lower baud rate channels more easily. Also, new network solutions based on open sourced 400GZR/ZR+ are promising to offer highly integrated solutions with reduced cost and power while promising improving performance numbers. Baud rate decisions in these applications are usually a tradeoff between space, power and spectrum efficiency

Karthik Balasubramanian is a Senior Optical Developer at Microsoft. He currently leads the efforts in planning and onboarding next generation long haul transponders and line systems for the Wide Area Network

Robert Maher, *Infinera, USA*
Presenatation Title: Next Generation Vertically Optimized Digital Coherent MODEMs
Abstract: As the symbol rates of commercialized line cards approach 100 GBd, vertical optimization of the coherent MODEM, where the constituent components of the digital coherent transceiver are co-designed, has become a pre-requisite in order to maintain the high levels of signal integrity required to encode, transmit and successfully decode higher order modulation formats. There are three core building blocks that are critical for high performance optics: digital ASIC design, integrated drive electronics with photonic integrated circuits and high-speed packaging. In this talk we will discuss the evolution of these core technologies that are required to realize the next generation of vertically optimized digital coherent MODEMs.

Robert Maher is a Senior Principal Engineer within the Advanced Optical System Group at Infinera. His work focusses on development and integration of next generation digital coherent MODEMs.

Radha Nagarajan, *Inphi, USA*
Presentation Title: Technology Options to Enable 800Gb/1.6Tb Coherent Modules
Abstract: Extending our 400G ZR systems designs, we explore options to implement 800Gb/1.6Tb coherent systems. These systems will push the baud rate limits >100GBaud, and will need new approaches to the design of the DSP and optical components, and employ 2.5/3D high speed co-packaging of optical and electronics to achieve optimum performance.

Dr. Radha Nagarajan is the CTO and SVP, Platforms at Inphi. Dr. Nagarajan brings more than 20 years of experience in the area of high-speed optical interconnects and design, development and commercialization of large-scale photonic integrated circuits. Dr. Nagarajan is a Fellow of the IEEE, OSA and IET (UK). In 2006, he shared the IEEE/LEOS Aron Kressel Award for his work on commercializing large-scale photonic integrated circuits. He has been awarded more than 195 US patents. He received his B.Eng. from the National University of Singapore, M.Eng. from the University of Tokyo, and Ph.D. from the UC, Santa Barbara.

Tom Williams, *Acacia (now part of Cisco Systems), USA*
Presentation Title: Silicon Photonics for Next-Generation Coherent Interconnects
Abstract: As adoption of 400G and above coherent interfaces are gaining momentum, the industry is looking toward next-generation solutions that operate above 100Gbaud. Higher speeds will push the limits of optical materials and packaging. Adoption of silicon photonics for coherent interfaces has become more

widespread, particularly for pluggable applications. This presentation will discuss the benefits and of silicon photonics in these next generation coherent solutions.

Tom is responsible for global marketing and communications activities for Acacia, which is now part of Cisco Systems. Prior to Acacia, Tom spent 14 years at Optium and Finisar Corporations, where he held various management roles, including Director of Product Line Management for high speed (>100G) transmission products. Tom has also held positions at Lucent Technologies and Northrop Grumman Corporation. He has an MS in Electrical Engineering from Johns Hopkins University and BS degrees in Electrical Engineering and Physics from Widener University.

Martin Zirngibl, *II-VI Incorporated, USA*
Presentation Title: Enabling Optics & Integration Technologies for Terabit Transmission
Abstract: The best way to deal with Shannon Limit is to respect it, and focus our engineering attention on other degrees of freedom -- WDM, multi-core fibers, etc. -- and on enhancing component technologies and integration to achieve lower cost and lower power. This includes component-level innovation in integration of modulation and lasing functions, improvement of net SNR, trading off certain parameters to optimize DSP complexity, new ways of packaging amplification in subsystems, and so on. From a market perspective, another way of looking at this is to consider that high-capacity systems may be a better fit for future shorter reach applications like DCI, co-location or client interfaces for transport networks.

Martin Zirngibl is currently Chief Technologist at II-VI Incorporated. Before the II-VI Incorporated acquisition of Finisar, he was the corporate CTO of Finisar, a position he held since 2018. Martin Zirngibl joined Finisar in 2016 as VP, fellow for technology responsible for strategy for coherent products. Prior to joining Finisar, Martin held progressive managerial roles at Nokia, Bell labs, as director of optical networking research and as executive director of device and subsystems research. He joined AT&T Bell laboratories as member of technical staff. Martin Zirngibl holds a PhD in physics for the Swiss Institute of Technology, Lausanne and a diploma in theoretical physics from the same Institute. He was named Bell Labs fellow in 2008. Martin has published over 100 scientific publications, has filed over 50 patents and wrote one book chapter.

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Technology Showcase: Parametric Measurements and Transceiver Test

Tuesday, 08 June, 16:00 – 16:30 PDT (UTC-7:00)

Speaker: Evan Smith, John Tucker, and Pavel Zivny

Optical communication development is strongly dependent on laser technology. Tektronix contributes by providing state-of-the-art tools through numerous stages of the value stream / workflows.

In production, Light-Current-Voltage (LIV) measurements are performed to screen for good and bad parts before shipped to customers. Keithley Source Measure Units (SMUs) are the instrument of choice for off- and on-wafer IV and LIV laser measurements.
Tektronix Sampling Oscilloscopes perform high speed transceiver testing at 26 GBd and 53 GBd, SM and MM with clock recovery while Tektronix Real Time Oscilloscopes perform analysis for electrical and optical anomalies and for rapid collection of waveform statistics.

Speakers: Evan Smith, Application Engineer, Wide Bandwidth Oscilloscopes Group;
John Tucker, Product Manager for Keithley SMU Instruments; Pavel Zivny, Domain Expert and IEEE 802.3 Representative, Wide Bandwidth Oscilloscopes Group

Presented By: Tektronix

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Technology Showcase: The Application of Expanded Beam Optics in the Next Generation of Data Centers

Tuesday, 08 June, 16:30 – 17:00 PDT (UTC-7:00)

Speaker: Duane Preiss, *Marketing Director – Optical Components*

This presentation will provide an overview of the benefits of expanded beam optics and 3M's revolutionary approach to providing expanded beam multifiber single mode and multimode fiber connectivity to support the increasing demands for speed and density in current and future data center architectures.

Presented By: 3M

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Technology Showcase: Recent Advancements in Photonic Test and Packaging Automation

Wednesday, 09 June, 04:00 – 04:30 PDT (UTC-7:00)

Speaker: Scott Jordan, *Head of Photonics, Director of Nanoautomation*

A rapid succession of radical new micro-robotic implementations has been brought to market to improve production economics for photonic devices. As photonic devices enter the mainstream, it is imperative that costs follow a rapid downward curve. The ultra-precision alignment requirements that recur in multiple test and assembly steps have been a roadblock to this and dominate production costs. Passive alignment techniques show promise for specific situations, but active alignment is here to stay. By reducing the cost of active alignment by typically 99% for today's devices, the new micro-robotic technology is driving improvement in production economics from wafer test to final package, and even onward to PCB and tray validation.

Presented By: PI (Physik Instrumente) LP

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Technology Showcase: Differential AC Coupling For Ultra Broadband Signal Lines : The Ideal Solution Up to 220GHz !

Wednesday, 09 June, 05:00 – 05:30 PDT (UTC-7:00)

Speaker: Olivier Gaborieau, *Product Line Manager*

Discover how Silicon Capacitors bring UBB systems to the next level of performances (i.e.: extremely low insertion loss) and integration (fully compatible with strong space constraint).
This presentation will detail how Murata's silicon technology overcomes the challenge to improve insertion loss, ESR/ESL, while reducing drastically footprint and thickness for AC coupling.

Presented By: Murata

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Technology Showcase: AIM Photonics Integrated Silicon Photonic Chip Fabrication and Test, Assembly & Packaging Offerings

Wednesday, 09 June, 05:30 – 06:00 PDT (UTC-7:00)

Speaker: Dr. David Harame, *COO, Director EPDA, Test & Packaging, and Process Development*

Join us for the latest updates in electronic-photonic design automation, multi project wafer platform offering, as well as test, assembly, and packaging. Learn how this PIC ecosystem enables quick turn photonic development through proof of concept, validation, qualification, and commercialization under one national institute, ensuring manufacturing readiness for years to come.

Presented By: AIM Photonics

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OFC Career Zone: The Benefits of Research

Wednesday, 09 June, 07:30 – 08:30 PDT (UTC-7:00)

Even before the pandemic many of us were wondering whether we're on the right career track, and now it seems like even more people are thinking about making a change. Perhaps you're one of them - maybe you'd like to try something completely different, or re-orient your work to do more good in the world. But making a big career shift can be intimidating, especially if you don't know others who have made the same kind of move. In 2016 Dr Rachel Mason did just that, leaving a secure position in astronomy to return to graduate school for an MS in sustainable agriculture and a highly uncertain path forwards. Now a scientist in a field that is very different from her original one, Dr Mason will share her motivations for taking this leap into the unknown, describe some experiences along the way, and reflect on the pros and cons of taking this route. She will show that you already have valuable knowledge and experience to bring to a new field,

while identifying important skills and personal characteristics to develop to make a successful transition. This talk will either inspire you to make a radical career change, or - just as important - prompt you to do something a little less drastic.

Please email awilliams@osa.org directly to RSVP.

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Technology Showcase: Addressing Mixed-Signal Requirements for High-Performance Optical Communications

Wednesday, 09 June, 10:00 – 10:30 PDT (UTC-7:00)

Speaker: Diwakar Vishakhadatta, *Vice President Optical Communications*

This showcase will review common requirements for high-performance Optical communications systems and how they can be addressed by Renesas' broad portfolio of mixed-signal solutions. Renesas Optical interconnect devices are tailored for these systems, including Power, MCU and ICs for Optical interfaces for PAM4 and Coherent deployments....

Presented By: Renesas Electronics America Inc.

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Network Operator Summit, Keynote: Neil McRae, Chief Architect, BT, UK

Wednesday, 09 June, 10:15 – 10:45 PDT (UTC-7:00)

Speaker: Loukas Paraschis, Infinera, USA

Moderator: Loukas Paraschis, *Infinera, USA*

Panel Description: Connecting for Good

Abstract: A 'feel-good' talk, revelling in how far we have progressed in the past 20 years, with plenty more to look forward to, from the perspective of a major international carrier. I will look at the enormous global impact enabled by optical fibre networks, assess where we have got to and then look at some of the exciting new technologies just around the corner. At this tough time for the planet, I want to appreciate all that has been achieved by the photonics industry.

Speakers: Neil McRae, *Chief Architect and MD for Architecture and Technology Strategy, BT, UK*

Biographies:

Neil McRae,*Chief Architect and MD for Architecture and Technology Strategy, BT, UK*

Neil is BT's Chief Architect and MD for Architecture and Technology Strategy leading Architecture and Technology strategy direction across all of BT, most recently leading BT's 5G programme. Neil's entire career has been linked to his personal purpose in which he believes getting people connected opens them to education and gives opportunity for anyone to be successful. Neil works with under-privileged teenagers helping them with technical skills in computer programming and electronic engineering and works as an Ambassador to the manned spaceflight programme.

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Technology Showcase: Optical Engines Evolution – 100Gbaud and Beyond

Wednesday, 09 June, 10:30 – 11:00 PDT (UTC-7:00)

Speaker: Parthiban Kandappan, *Chief Technology Officer*

This session will explore the evolution of coherent optical engines starting from the current generation of 7-nm technology. Included in the discussion will be how the industry progresses and continues to provide meaningful networking improvements as we move beyond 96 Gbaud and approach Shannon's limit. During the sessions we take a closer look at the impact of materials and the importance of vertical integration in the evolution of both pluggables and embedded solutions for applications across the network.

Presented By: Infinera

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OSA Booth Tech Talk: LIDAR, Boom or Bust?

Wednesday, 09 June, 11:00 – 11:30 PDT (UTC-7:00)

Martin Zirnginbl*, II-VI Incorporated, USA;* Cibby Pulikkaseril, *Baraja, Australia*

Special Purpose Acquisition Companies (SPAC) are investing billions of dollars in a variety of autonomous LIDAR companies despite the fact that there is no significant LIDAR revenue as of today. We will discuss the technical and application hurdles that must be overcome in order for LIDAR to become a business generating meaningful revenue and profits.

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Panel I: Reality Check for 5G Networks: Network Operator Perspective

Wednesday, 09 June, 11:00 – 12:30 PDT (UTC-7:00)

Speaker: Mehran Esfandiari, NTE Consulting, USA

Moderator: Mehran Esfandiari, *NTE Consulting, USA*

Panel Description:

5G promises to revolutionize society and industry by enabling service provider & network operators to provide a wide range of services, such as enhanced Mobile Broadband (eMBB), Ultra-Reliable Low Latency Communications (uRLLC) and massive Machine-Type Communications (mMTC). This diverse set of services place different requirements on the transport network, including x-haul optical architectures, RAN, Edge Computing (MEC), latency & reliability. This Network Operator Summit session will assemble speakers from leading edge operators around the world to share the current state of affairs and offering a reality check on operating 5G networks.

Key questions to be addressed are:

- What is the current status and challenges of 5G architectures from real-world deployments, experiments, prototypes, and testbeds? What are the time frames for implementation?
- How would 5G network slicing be implemented? By 5G application type (eMBB, uRLLC, mMTC)? By virtual or physically separated connections or networks? By control plane and orchestration entities only?
- What are the requirements on latency and reliability with different service types, what are the most stringent ones? How do these impact the RAN x-haul access/metro/core architecture?
- How does Edge Computing and Disaggregated Cell Site Gateway, CU/DU impact the traditional separation between mobile, access, and metro/aggregation networks?
- What are the tradeoff and benefits of distributed-RAN vs. centralized-RAN vs. cloud-RAN on x-haul networks? What can edge cloud do to address latency issue and are these scalable solutions?
- In which part of x-haul would CWDM & DWDM features such as dynamic reconfiguration, super-channels, spectrum routing, and subcarrier aggregation be beneficial?
- What are the most promising architectures for coherent optics or mini-ROADMs in the 5G access? At which level could a mini-ROADM expand to mid-haul and back-haul networks?
- Where are the best fit and application for OTN and/or Ethernet aggregation in mid & back-haul transport networks? How does FlexO and Flex-E weigh in?
- For operators with fixed broadband networks, how can those networks be optimally leveraged for cost-effective 5G transport?

Speakers:

Philippe Chanclou, *Orange Labs, France*
Presentation Title: 5G Ready Fibre to the Antenna

Andrew Lord, *BT, UK*
Presentation Title: Data and Control Plane Technologies that Will Enable Future 5G Applications

Kosuke Nishimura, *KDDI Research, Japan*
Presentation Title: Mobile Fronthaul for Accommodating Enormous Data Traffic in Final Phase of 5G and Beyond

Mark Watts, *Technical Staff Member, Verizon, USA*
Presentation Title: Cohesion between 5G Mobile Wireless and Fixed Optical Based Wireline Networks

Biographies:

Philippe Chanclou, *Orange Labs, France*
Presentation Title: 5G Ready Fibre to the Antenna
Abstract: Today's challenges of 5G deployment in Orange's network will be addressed. A view of how/when optical fibre serves Radio Access Network (RAN) backhaul, midhaul and fronthaul, will be addressed especially with the coming open-source supplier ecosystem based on O-RAN initiative. A focus

on short reach transceivers and optical access networks will be proposed to achieve Fibre-to-The-Antenna (FTTA).

Philippe Chanclou joined the R&D facilities of France Telecom in 1996 where he worked on the research of active and passive optical telecommunications functions for access networks. In 2000, he joined the IMT Atlantique as a senior lecturer where he was engaged in research on optical switching and optical devices using liquid crystal for telecommunications. During 2001 to 2003, he has participated to the foundation of Optogone Company. Since 2004, he joined Orange Labs where he was engaged in research on the next generation optical access networks. He is now manager of Fixed Access Networks team . This team is an active about FTTx topics for Home (Passive Optical Network), Enterprise (Passive Optical LAN) and Antenna (including the transport of radio access network interfaces “xhaul”).

Mehran Esfandiari, *NTE Consulting, USA*

Mehran Esfandiari is a Technical Lead Consultant with more than 20 years of experience in Tier-1 Service Provider networks of AT&T and SBC. His leadership expertise on network architecture, requirements, planning, and deployment focuses on Metro/Backbone Transport, 5G Mobile xHaul, DCI, and WAN Networks. Recently he has been involved in design and solution architectures for SDN based ROADM/OTN, Packet-Optical Networking, Open Source initiatives, CDN, Mobile Edge Cloud, and C-RAN network infrastructure. He has been part of the OFC Technical Committee for many years and has served as General Program Chair & Technical Program Chair of OFC in the past. He is based in the San Francisco Bay Area.

Andrew Lord, *BT, UK*
Presentation Title: Data and Control Plane Technologies that Will Enable Future 5G Applications
Abstract: Today's challenges of 5G deployment in Orange's network will be addressed. A view of how/when optical fibre serves Radio Access Network (RAN) backhaul, midhaul and fronthaul, will be addressed especially with the coming open-source supplier ecosystem based on O-RAN initiative. A focus on short reach transceivers and optical access networks will be proposed to achieve Fibre-to-The-Antenna (FTTA).

Andrew heads BT’s optical core, access and quantum research. He was Chair of the Optical Fiber Communications Conference 2017 in Los Angeles. He is Visiting Professor at Essex University. He won the prestigious BT Martlesham Medal in 2018. He recently led the 5G Metro-Haul EU-funded project.

Kosuke Nishimura, *KDDI Research, Japan*
Presentation Title: Mobile Fronthaul for Accommodating Enormous Data Traffic in Final Phase of 5G and Beyond
Abstract: 5G will provide capacity of 20 Gbit/s as maximum users' throughput for downlink in its final phase, and further capacity expansion is expected for Beyond-5G. Our recent achievements of research and development is presented regarding mobile fronthaul transmission based on analog Radio-over-Fiber scheme, which has potential sustainability from 5G toward Beyond-5G.

Kosuke Nishimura is a senior expert in KDDI Research, Inc. He is currently working on research and development of transmission technology and network architecture for mobile fronthaul in 5G and B5G mobile system.

Mark Watts, *Technical Staff Member, Verizon, USA*
Presentation Title: Cohesion between 5G Mobile Wireless and Fixed Optical Based Wireline Networks
Abstract: Interworking between 5G Mobility and Fixed Optical Access Application is rapidly increasing in

importance for users and network operators.Use cases are converging, with overlapping network features and functionality, and in some cases, duplicative.

Mark T. Watts is a Distinguished Member of the Technical Staff Architect at Verizon Communications. He joined Verizon's predecessor Bell Atlantic in 1997 with various increases in responsibility. He has been primarily focused on physical layer transport, data and IP engineering, and most recently wireless transport for 4G and 5G network and architecture. Mark graduated from Villanova University with a Degree in Mechanical Engineering in 1996.

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OSA Booth Tech Talk: Silicon Photonic Circuit Design

Wednesday, 09 June, 12:00 – 12:30 PDT (UTC-7:00)

Wim Bogaerts, *Univ. of Ghent, Belgium*

In the past decade, photonic chip design has slowly evolved from physical electromagnetic simulations to higher-level circuit design. The procedures, tools and methods closely resemble those of electronic design automation (EDA), which is useful, as photonic-electronic codesign becomes more and more important to realize complex photonic functions. But the differences between photonics and electronics also introduces quite some challenges, especially in fast and accurate photonic circuit simulation and assessing the effects of fabrication variations on the yield of the circuits. In particular, silicon photonics technology is exceptionally sensitive to nanometer-scale deviations. We will discuss the current state of photonic circuit design, and the challenges lying ahead to make photonic design as reliable as its counterpart for electronics.

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Next Generation Optical Interfaces – An IEEE and Industry Update

Wednesday, 09 June, 13:30 – 14:30 PDT (UTC-7:00)

Session Description:

Session Description:

The IEEE panel on next gen optical interfaces will cover new developments happening in the industry and IEEE which include new low-cost 100 Gbps coherent spec, "400ZR+" spec, and new work that covers 800 GbE or co-packaging. This panel will show the latest results, drivers, customer needs, etc. on these topics with a high level / applications focus.

Moderator:

Mark Nowell, *Cisco, Canada*

Mark Nowell is a Cisco Fellow in Cisco's Data Center Business Unit. His focus is on next generation interconnect technology innovation to meet Cisco's needs. Mark is also active within the industry standards and forums and has chaired multiple IEEE 802.3 Ethernet projects. He represents Cisco on various industry alliances and Consortium. Mark also chairs a number of industry MSA (Multi-source Agreement) groups focusing on next generation optical module form factors (QSFP-DD, QSFP-DD800) and optical interface signaling technology (100G Lambda MSA, 400G BiDi).

Presenters:

Vipul Bhatt, *II-VI Incorporated, USA*
Presentation Title: Transceiver Implementation Perspective on Next-gen Client Optics

Scott Schube, *Intel, USA*
Presentation Title: Next-Generation Bandwidth Scaling with Integrated Optics

Radha Nagarajan, *Marvell, USA*
Presentation Title: Next Generation Data Center Interconnects at 800G and Beyond

Tom Williams, *Acacia (now part of Cisco Systems), USA*
Presentation Title: The Launch of 400G Coherent Pluggables and What Comes Next

Biographies:

Vipul Bhatt, *II-VI Incorporated, USA*
Presentation Title: Transceiver Implementation Perspective on Next-gen Client Optics
Abstract: More than two decades of evolution of client-side optical transceivers have given them some core characteristics – standardized interfaces, interoperability, high volume, and continuous improvements in cost efficiency and power efficiency. As the market prepares to move to “beyond 400G”, these transceivers will see yet another round of transformation in lane speed and bandwidth density. We will examine components, device technologies and link level considerations that will ensure the success of such transceivers in the market.

Mr. Vipul Bhatt is the Sr. Director of Strategic Marketing, Datacom, at II-VI Incorporated. Vipul has a track record of over 25 years of pioneering product and business development in optical networks, spanning companies such as Corning, Cisco and Inphi. He has been an active contributor to optical standards development in IEEE. He holds a Master’s Degree in Electrical Engineering from Columbia University, New York.

Radha Nagarajan, *Marvell, USA*
Presentation Title: Next Generation Data Center Interconnects at 800G and Beyond
Abstract: 400G data rates are well into deployment for both inter (16QAM, 400ZR) and intra (PAM4, DR4/FR4) data center applications. We explore the options for the next data rate at 800G and beyond. We focus on the technology, transmission format and relative merits of the various options that are being proposed in the industry. We explore the tradeoffs between the PAM4 and 16QAM transmission formats for these applications.

Dr. Radha Nagarajan is the CTO and SVP, Platforms at Marvell. Dr. Nagarajan brings more than 20 years of experience in the area of high-speed optical interconnects and design, development and commercialization of large-scale photonic integrated circuits. Dr. Nagarajan is a Fellow of the IEEE, OSA and IET (UK). In 2006, he shared the IEEE/LEOS Aron Kressel Award for his work on commercializing large-scale photonic integrated circuits. He has been awarded more than 195 US patents. He received his B.Eng. from the National University of Singapore, M.Eng. from the University of Tokyo, and Ph.D. from the UC, Santa Barbara.

Scott Schube, *Intel, USA*
Presentation Title: Next-Generation Bandwidth Scaling with Integrated Optics
Abstract: This talk will cover emerging technology and market trends and challenges as optical transceivers evolve to support the massive I/O bandwidths needed for scaling next-generation high-volume data center applications. We will discuss different paths to scale optical link bandwidth to 800G, 1.6T, and beyond; industry standardization options; and new optics device and packaging technologies, focused particularly on integrated optics technologies such as silicon photonics.

Scott has worked in the optical communications component industry for 20 years in both technical and marketing roles. As an engineer he developed Gigabit Ethernet transceivers for AMP Lytel and then at Tyco Subcom he designed high-performance receiver line cards for ultra-longhaul undersea communication. Scott went on to a variety of marketing and management roles, from technical marketing to product management and strategic marketing, at Intel OPD and NeoPhotonics, as well as senior analyst at optics industry research firm LightCounting. Currently Scott is senior director of strategic marketing and business development in Intel's silicon photonics group, where he has helped grow the business from zero to one of the leading global optical transceiver suppliers.

Tom Williams, *Acacia (now part of Cisco Systems), USA*
Presentation Title: The Launch of 400G Coherent Pluggables and What Comes Next
Abstract: The industry has made a major investment in standardized 400G pluggable solutions over the last several years. These modules are shipping in multiple configurations and expected to ramp significantly over the second half of 2021. Network operators plan to use a mix of deployment models to leverage the power, performance, and operational benefits offered by these solutions. Topics to be explored include where these interoperable interfaces will be deployed, how will they impact the rest of the coherent market and where do we go from here?

Tom is responsible for global marketing and communications activities for Acacia, which is now part of Cisco Systems. Prior to Acacia, Tom spent 14 years at Optium and Finisar Corporations, where he held various management roles, including Director of Product Line Management for high speed (>100G) transmission products. Tom has also held positions at Lucent Technologies and Northrop Grumman Corporation. He has an MS in Electrical Engineering from Johns Hopkins University and BS degrees in Electrical Engineering and Physics from Widener University.

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Open Eye MSA: Road to Low Cost PAM-4 Optics

Wednesday, 09 June, 13:30 – 14:30 PDT (UTC-7:00)

Session organized by

Session Description: Open Eye

Minimizing the need for signal processing in optical modules has many advantages including significantly lowering latency, power consumption and cost. The independent Open Eye industry consortium is committed to investing its amassed innovation and engineering resources for the development of an industry-standard optical interconnect, leveraging seamless component interoperability among a broad group of industry-leading technology providers, including providers of electronics, lasers and optical components.

Moderator:

Marek Tlalka, *MACOM, USA*

Prior to joining MACOM, Marek worked at Mindspeed Technologies, Luxtera, Conexant, Applied Digital Access and GTE Communications Systems. Marek has over 30 years of experience in the telecommunications field covering areas such as Engineering, Product Management, Marketing and Sales.

Marek received his BSEE from Illinois Institute of Technology and his MBA from San Diego State University.

Panelists:

Brad Booth, *Microsoft, USA*
Presentation Topic: End User (Cloud)

Mark Kimber, *Semtech, USA*
Presentation Topic: Analog Semiconductors

Raju Kankipati, *MACOM, USA*
Presentation Topic: 100G Optics

Greg Le Cheminant, *Keysight Technologies, USA*
Presentation Topic: Test

Biographies:

Brad Booth, *Microsoft, USA*
Presentation Topic: End User (Cloud)

Brad Booth is a distinguished leader in technology development and standardization. He is a Principal Hardware Engineer in Microsoft's Next Cloud System Architecture Group where he leads the development of next generation optical connectivity solutions for Microsoft's Cloud and AI datacenters. Previously, Brad has held technology strategist and engineering positions at Dell, Intel and Bell-Northern Research. The holder of over 20 patents related to networking technologies, he has also received awards for his contributions to industry consortia and IEEE 802.3 Ethernet standards.

Mark Kimber, *Semtech, USA*
Presentation Topic: Analog Semiconductors

Mark Kimber is the Principal Product Definition Specialist at Semtech Corporation. Mark received the BE (Elect) degree from the University of Queensland in 1984. Since then he has worked on research and product development at GEC Hirst Research Centre, STC Laboratories, Bell Northern Research, Nortel, Bookham, Gennum and Semtech. Mark currently works on product definition for Semtech products and is a contributor to various standards groups.

Raju Kankipati, *MACOM, USA*
Presentation Topic: 100G Optics

Raju Kankipati is a Senior Director of Product Management at MACOM, focused on providing high volume photonic solutions to customers based on MACOM's broad portfolio of optical and electronic component technologies. Prior to joining MACOM, Raju worked at Arista Networks and Cisco Systems as a Product Manager. During this time he collaborated closely with data center customers to bring unique switching products as well as Optical transceivers to market, that helped customers deploy 40G and 100Gbps products for highly scalable and efficient networks. Raju started his career as an Optics Engineer at Opnext and later held various roles in sales and marketing at the company. Raju received his MBA degree from UC Berkeley (Haas School of Business) and completed his Bachelor of Engineering in Electronics from BITS, Pilani in India.

Greg Le Cheminant, *Keysight Technologies, USA*
Presentation Topic: Test

Greg Le Cheminant is a Measurement Applications Specialist and Strategic Planner for digital communications analysis products in the Internet Infrastructure Solutions Group. He is responsible for development of new measurement applications and products for the group's optical communications test products. He represents Keysight on several industry standards committees. Greg's experience at Keysight/Agilent/Hewlett-Packard began in 1985 with five years in manufacturing engineering, and the remainder in various technical marketing positions. He is a contributing author to four textbooks on high-speed digital communications and has written numerous technical articles on test related topics. Greg earned BSEET and MSEE degrees from Brigham Young University.

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Panel II: Less Hyper Scale and More Co-location and Compute at the Edge?

Wednesday, 09 June, 13:30 – 15:00 PDT (UTC-7:00)

Speaker: Robert Blum, Intel, USA

Moderator: Robert Blum, *Intel, USA*

A lot of focus has been put on the economy and scale of hyper scale data centers. The last decade witnessed a massive scale out of data centers, some of which contain upwards of a hundred thousand severs and require more than a hundred Megawatts of power. However, security, privacy and data sovereignty considerations have also required the use of much smaller data centers closer to the end user. And with the roll out of 5G and the need for more and more data tied to time critical applications such as real time maps for autonomous driving, edge and co-location data centers are becoming an increasingly critical component of the network as well.

This panel will discuss the latest trends in data centers from an infrastructure and networking hardware perspective. What vectors and opportunities exist to reduce power consumption, size, and cost, what architectures are being considered inside data centers, and how are data centers evolving and being linked together at the regional and global scale to address the needs of the new decade?

Speakers:

Ed Baichtal, *Equinix, USA*

Sauabh Sandhir, *Nokia, USA*

Chongjin Xie, *Alibaba, USA*

Zuowei Shen, *Google, USA*

Dan Pitt, *MEF Forum*, *USA*

Biographies:

Ed Baichtal, *Equinix, USA*

Ed Baichtal is currently a Solutions Architect with over 25 years of industry experience including managed IT services. He has developed and deployed countless hybrid deployments, and currently guides customers on their IOA journeys at Equinix, providing network standards to expand their business.

Robert Blum, *Intel, USA*

Robert Blum is Director of Marketing and New Business for Intel's Silicon Photonics Product Division. Prior to joining Intel, Robert was Director of Strategic Marketing at Oclaro Inc., and held various Director of Product Management and Marketing roles for Oclaro's telecommunications products and consumer laser portfolio. Before joining Oclaro, Robert was Product Line Manager for optical transmission components at JDS Uniphase Corporation and held various engineering and marketing management roles at Gemfire Corporation, all in California. Robert worked at Deutsche Telekom's research labs in Darmstadt, Germany, while completing his master's thesis and holds a doctorate degree in Physics from the University of Technology in Hamburg. He has also studied and done research at Ecole Polytechnique Fédérale in Lausanne, Switzerland, and at Stanford University, California.

Dan Pitt, *MEF Forum*, *USA*

Dan Pitt, a leading voice of SDNFV, serves as senior vice president of MEF, applying SDN, NFV, Cloud, Disaggregation, and Open Source to the offering of new, dynamic services across a global system of automated networks. Prior to MEF he was executive director of ONF from 2011-2016 and served as Dean of Engineering at Santa Clara University. His industrial career includes Nortel Networks, Bay Networks, HP Labs, and IBM Research Zurich. He holds a B.S. from Duke and M.S. and Ph.D. degrees from the University of Illinois and is a Fellow of the IEEE.

Sauabh Sandhir, *Nokia, USA*

Saurabh Sandhir heads Product Management at Nuage Networks. Saurabh brings over 17 years of experience leading cross-functional engineering, product management and marketing teams focused on networking software products. Prior to Nuage, Saurabh was Head of Technology Strategy at Ericsson. Before that, Saurabh held a variety of leadership roles during a 13 year tenure at Juniper Networks including product line responsibility for Juniper's network programmability and NFV platforms. Saurabh played key role in building Juniper's SDN partner and channel programs and defining the SDN architecture/strategy leading to the acquisition of Contrail Systems.

Saurabh has an undergraduate degree in Computer Science from the Indian Institute of Technology, Delhi, a Masters in Computer Science from Purdue University and an MBA from University of California, Berkeley.

Zuowei Shen, *Google, USA*

Zuowei Shen is a senior staff hardware engineer at Google technical infrastructure, working in optical interconnect and system architecture. Her research interests include network interconnect, signal integrity, server/storage/network hardware design, optics to machines and innovative system architecture. Prior to joining Google, Zuowei was at Avago Technology , where she works on signal integrity and optical transceiver design. Zuowei received her Ph.D in Electrical and Computer Engineering and M.S. degree in Statistics from University of California, Davis. She received her B.S.degree in Electrical Engineering from Peking University.

Chongjin Xie, *Alibaba, USA*

Chongjin Xie is a senior director in Alibaba Group, leading an optical network team working on datacenter optical interconnect. Prior to joining Alibaba in 2014, Dr. Xie was a Distinguished Member of Technical Staff at Bell Labs, Alcatel-Lucent, doing research on optical communications. He was a post-doctor at

Chalmers University of Technology from 1999 to 2001, and received his M.Sc. and Ph.D. degrees from Beijing University of Posts & Telecommunications in 1996 and 1999, respectively. Dr. Xie has published one book, 4 book chapters and over 200 papers. He is a Fellow of OSA and a senior member of IEEE.

[top]

OSA Booth Tech Talk: How I Use Python to Automate My Experiments

Wednesday, 09 June, 15:00 – 15:30 PDT (UTC-7:00)

Nicolas Fontaine, Nokia Bell Labs, USA In this tech talk, we will show how to align a mode multiplexer in an optical laboratory. A bunch of open source software is used, including python, to automate positioning stages, data acquisition, and result processing.

Open Networking Summit

Tuesday, 08 June 14:00 – 16:00

Towards Converged Open Packet-optical Networks

Organizers: Filippo Cugini, *CNIT, Italy;* Wataru Ishida, *NTT Electronics America, USA;* Victor Lopez, *Nokia, Spain*

This summit will provide the most recent updates and trends on open technologies, architectures and interfaces in Optical Networking. The event will be divided in two parts.

In the first part, invited speakers will give their views on network disaggregation and how it is driving the design of new devices and technologies such as open optical and packet/optical transponders (e.g., Phoenix, Cassini, etc.), open source network operating system, and open planning tools. The speakers will also report on the progress in initiatives such as OpenRoadm, Telecom Infra Project, OpenConfig, and ONF. Finally, relevant room will be devoted to network deployments, covering both access and metro/inter-DC real-world implementations.

In the second part, a panel discussion will enable Operators and Vendors to debate on deployment strategies, challenges in open networking as well as to discuss the expected trends towards fully converged open packet-optical networks.

Speakers:

Vittorio Curri, *Politecnico di Torino, Italy*
Oscar González de Dios, *Telefonica, Spain*
Fred Gruman, *Fujitsu, USA*
Hideki Nishizawa, *NTT, Japan*
Lihua Yuan, *Microsoft, USA*

Rump Session

Did the Optics Industry Blunder by Switching Intra-Datacenter Links from NRZ to PAM4?
Will More DSP like PAM6 and Coherent Follow, or Will WDM and Parallel Save the Day?

Session Organizer and WDM Team Captain: Chris Cole, *II-VI Incorporated, USA*
WDM Team Provocateurs: Shigeru Kanazawa, *NTT*, *Japan*; Boris Murmann, *Stanford University, USA:* Bardia Pezeshki, *Avicena Tech*, *USA;* Peter Winzer, *Nubis Communications, USA*

Session Organizer and DSP Team Captain: Ilya Lyubomirsky, *InPhi*, *USA*
DSP Team Provocateurs: Yi Cai, *ZTE, USA;* Dan Sadot, *Ben Gurion University*, *Israel;* Henry Sun, *Infinera*, *Canada;* Xiang Zhou, *Google, USA*

Description from WDM Team:
PAM4 was chosen for bandwidth limited electrical channels by the IEEE Ethernet Group in 2012. Modulation format for 50G λs was debated by the IEEE in 2015. Shannon provided clear guidance to stick with NRZ because the optical channel is limited by SNR and not bandwidth. Unfortunately, because the optics industry is the tail on the IC industry dog, PAM4 was chosen to reuse ASIC SerDes technology already in development. This unnecessarily and permanently locked in lower SNR and higher power for optical links. PAM4 50G λs will ship in the millions despite availability of mature 50GBaud technology. Shannon was again ignored by the IEEE for 100G λs and appears likely to be ignored for 200G λs. However, emerging applications not tied to Ethernet are returning to communication theory fundamentals and defining higher channel count lower-order modulation WDM and Parallel links.

Questions for Discussion from WDM Team:

- What are the SNR and power advantages of NRZ over PAM4 optics?
- How does photonic integration change channel count vs. modulation trade-off?
- How does co-packing impact channel characteristics and optimum modulation?
- Are Coherent telecom advantages of any use in the datacenter?
- Will the datacom optics industry continue its self-destructive migration off the higher-order modulation cliff with each future datacom rate increase?

Description from DSP Team:
Analog direct detection technology dominated transport optics for many years. Capacity per fiber grew simply by increasing the modulation rate and number of λs. Around the year 2000, modulation rate reached a 40Gbaud limit because of fiber chromatic and polarization mode dispersion, and DWDM λ spacing reached a practical 50 GHz limit. DSP Coherent technology came to the rescue by adaptively compensating for fiber impairments and by increasing per λ capacity, resulting in lower deployment and operating costs. Analog direct detection technology went extinct, along with multiple start-ups. History is now repeating in the datacenter. Impairments such as component bandwidth, electrical and optical reflections, laser noise, and chromatic dispersion limit performance of higher data rates. DSP again brings relief and cost reduction by equalizing out these impairments and increasing per λ capacity. In optical communications as in other fields, bets against CMOS, the enabler of DSP, always lose.

Questions for Discussion from DSP Team:

- What are the optimum modulation formats for optical and electrical channels?
- Will reduced-complexity DSP bring Coherent into the datacenter?
- Which is more important inside the datacenter: cost or power?
- Is ADC power reduction tracking CMOS node scaling or is it plateauing?
- Will the datacom optics industry snatch defeat from the jaws of victory and switch back to the Analog direct detection path of obsolescence?

Format:

- Introductory presentations by WDM and DSP Team Captains, followed by one content slide and one punch line slide presented by alternating WDM and DSP Team Provocateurs, adding up to 50% of session time.
- Vigorous audience participation after each presentation, with Team Captains facilitating wide ranging discussion, adding up to the other 50% of session time.
- Attendees come prepared with tough questions, insightful comments, and different perspectives to challenge the Provocateurs and broaden the discussion.
- Lack of objectivity, unabashed partisanship, and exuberant support of your favorite Team are strongly encouraged, but please no hooliganism.

Workshops

The workshops provide opportunities to discuss and debate the latest technologies. Workshop topics are controversial in nature and meant to be highly interactive amongst both the speakers and the audience. The format of each session is determined by the organizers. In the past, many workshops have consisted of a series of short presentations (5 to 10 minutes) from people involved in the field followed by a panel discussion driven by questions from the audience.

All times are Pacific Daylight Time (UTC-07:00)

Cognitive Network Automation: How Smart Can Optical Transport Networks Be?

Sunday, 06 June
05:00 - 07:30

Organizer:

Johannes K. Fischer, *Fraunhofer Heinrich-Hertz-Institut, Germany*
Lida Galdino, *Univ. College London, UK*
Paolo Monti, *Chalmers University of Technology, Sweden*
Christine Tremblay, *École de Technologie Supérieure, Montréal, Canada*

Description:

5G and Beyond 5G services are expected to facilitate a transition towards smart communication infrastructures where network operations will account – in an automated fashion – for the specific end-user requirements and the network's status itself.

This workshop aims at stimulating a debate over which challenges should be overcome in the metro/core transport segment and what advantages can be foreseen when enabling this transition.

On the one hand, it is expected that network automation will help supporting dynamic and real-time provisioning of services (e.g., via cognitive, intent-based, zero-touch operations), optimizing the usage of infrastructure capacity (e.g., reactive/proactive re-routing, defragmentation, combining photonic layer programmable infrastructure with advanced software applications), and lowering CAPEX and OPEX costs. All these benefits will be achieved by a combination of intent-based operations, Artificial Intelligence (AI) mechanisms, and Machine Learning (ML) tools supported by a highly flexible and software-driven data plane providing detailed physical-layer information the data analytics framework.

On the other hand, it can be expected that the benefits brought by network automation will come at a cost in terms of an increased complexity to guarantee: (i)

service quality, (ii) secure and reliable operations, and (iii) consistency of operations across the various technological and administrative domains.

Speakers:

Harald Bock, *Infinera, Germany*
Talk Title: A Path Towards a Smart Zero-touch Transport Network

David Côté, *Ciena, Canada*
Talk Title: Action Recommendation Engine: Using AI to Automate Network Operations

Ori Gerstel, *Sedona Systems, USA*
Talk Title: How Smart Can Transport Networks Become Given the Realities of Service Provider Networks?

Takeshi Hoshida, *Fujitsu, Japan*
Talk Title: Advanced Optical Monitoring in DSP-based Receiver

Daniel Kilper, *Trinity College Dublin, Ireland*
Talk Title: Smarter Hardware vs Smarter Software: Where is the Sweet Spot?

Stefan Melin, *Telia Company, Sweden*
Talk Title: Key Areas for Improvements in Optical Networks –How Automation Can Help Us As an Operator

Stephan Neidlinger, *ADVA, Germany*
Talk Title: Real-life Achievements and Gaps in Autonomous Optical Networks

Yvan Pointurier, *Huawei, France*
Talk Title: Network Automation – an Equipment Maker's Perspective

Cristina Rottondi, *Politecnico di Torino, Italy*
Talk Title: ML-based QoT Estimation with Small Training Datasets and Under Measurement Uncertainty

Jesse Simsarian, *Nokia, USA*
Talk Title: Network Automation: Progress and Pitfalls

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Optical Signal Processing: Neuromorphic Computing and Quantum Information Processing

Sunday, 06 June
05:00 - 07:30

Organizer:

Xi (Vivian) Chen, *Nokia, USA*
Fred Kish, *North Carolina State Univ., USA*
Chigo Okonkwo, *Technische Universiteit Eindhoven, Netherlands*

Description:

Recently, there has been a resurging interest in using light to build processors to meet computational demands and potentially enable new applications such as high-performance computing, solving optimization problems, accelerating deep learning, quantum processing, etc. Compared to digital signal processing, optical processing offers unique advantages such as ultra-fast processing time and massive parallelism. Coupled with the advances in photonic integration and a large-scale semiconductor manufacturing ecosystem, devices use optical signal processing can be made small form factor and potentially low power consumption. This workshop will cover the current status, prospects, and challenges of the field in using light for neuromorphic computing, machine learning, and quantum information processing.

Speakers:

Neuromorphic Computing

Sylvain Gigan, *Sorbonne Université, France*

Huaiyu Meng, *Lightelligence Inc., USA*

Paul Prucnal, *Princeton Univ., USA*

Kathy Ludge, *TU Berlin, Germany*

Quantum Information Processing

Andrew Weiner, *Purdue, USA*

Mark Thompson, *PsiQuantum, USA*

Jelena Vuckovic, *Stanford Univ., USA*

Will Multiband, Multidimensional, SDM Effectively Address the Need for Increased Network Capacity?

Sunday, June 6, 2021
5:00 AM - 7:30 AM

Organizer:

Antonio Napoli, *Infinera Corporation, Germany*
Taji Sakamoto, *NTT, Japan*
Yikai Su, *Shanghai Jiao Tong University, China*

Description:

Capacity demand is rapidly and heterogeneously growing in all telecommunication sectors. This is commonly addressed by deploying multiple commercial C-band (conventional SDM) and, recently, C+L-band (multi-band) systems. The two approaches can coexist and leverage wavelength, polarization, and space.

For now, these solutions can do the work: there are enough fibers, and the techniques to deploy them are becoming less expensive. Furthermore, the maturity of the entire ecosystem is very high.

Current forecasts see a continuous capacity growth in almost every application space, with a clear path towards Pb/s optical networks. In this context, more advanced SDM techniques have been proposed. All these solutions contribute to the linear part of the Shannon equation, but they are not commercial yet. Among them, we recall multi-core/-mode fibers and transmission beyond C+L.

Multi-core/-mode SDM transmission has been in the spotlight over the past decade. Extensive research efforts have been and are carried out, showing the great potential of this approach to scale the capacity of optical systems. Standardization activities recently started on the fibers and components. Deployed testbeds for SDM transmission are becoming available. Nevertheless, there is not yet a clear business case to justify the development of the required ecosystem and subsequent commercialization. Similar conclusions are valid for transmission beyond C+L. Last, several practical aspects must be addressed, e.g., splicing, core identification, fan-in/fan-out, performance variability, and cabling.

This workshop aims at reaching consensus on the initial applications – e.g., requirements of submarine systems versus data centers are different – that might lead to the deployment of Petabit optical networks. Furthermore, we aim at analyzing when / where all techniques will be needed, and we will debate about:

- Until when will conventional SDM be sufficient in terms of transmission and switching capacities? How much can C+L extend his lifetime?

- What are the drivers for ultra-high-capacity multiplexing beyond Petabit optical networks?
- What are the effective technical approaches to ultra-high-capacity multiplexing? In what physical dimensions?
- What are the enabling devices and challenges? What are the roadmaps and where are we?
- When will the industry likely adopt these novel solutions? Which is the killing app that will kick-off the enhanced SDM or wideband solutions?
- What is the gap between current maturity and commercialization? What is the technology or innovation that can help to bridge the gap?

A final summary, with pros and cons for all solutions, will be the main outcome of the workshop.

Speakers:

The workshop is organized in three teams discussing the three approaches. Each team consists of an operator, a vendor, one or more academic / research institute, and one fiber manufacturer.

The team members are listed hereafter:

Conventional SDM with Multi-fibers

Ming-Jun Li, *Corning, USA (Fiber Manufacturer)*

Behnam Shariati, *Fraunhofer, Germany (Academic)*

Oleg Sinkin, *Subcom, USA (Vendor)*

Ioannis Tomkos, *University of Patras, Greece (Academic)*

Glenn Wellbrock, *Verizon, USA*

Multi-band

Romain Brenot, *Huawei, China (Vendor)*

Vittorio Curri, *Politecnico di Torino, Italy (Academic)*

David DiGiovanni, *OFS, Japan (Fiber Manufacturer)*

Erwan Pincemin, *Orange, France (Operator)*

SDM with Multi-core / -mode

Cristian Antonelli, *Univ. L'Aquila, Italy (Academic)*

Haoshuo Chen, *Nokia Bell Labs, USA (Vendor)*

Itsuro Morita, *KDDI, Japan (Operator)*

Georg Rademacher, *NICT, Japan (Research Center)*

Ryuichi Sugizaki, *Furukawa, Japan (Fiber Manufacturer)*

Two referees will determine which team has been more convincing

Joseph Kahn, *Stanford University, USA*

Qunbi Zhuge, *Shanghai Jiao Tong University, China*

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Optical Wireless Communications: What Is Stopping Us?

Sunday, 06 June
08:00 - 10:30

Organizer:

Volker Jungnickel, *Fraunhofer, Germany*
Norman Swenson, *Norman Swenson Consulting, USA*

Description:

This workshop aims at figuring out what role optical wireless communications (OWC) could play in Beyond 5G and 6G Wireless Networks. OWC distinguishes into long- and short-range applications. OWC gains importance where it can leverage the unique selling points of the light medium as opposed to RF, such

as ultra-high capacity, immunity against electromagnetic interference, the possibility to communicate wirelessly through water, and the ability to provide additional security. There are synergies when combining OWC with radio technology, yielding a hybrid system having better properties than the individual technologies could offer.

Short-range OWC systems provide high-speed mobile access in hotspot areas, also denoted as Light Fidelity (LiFi). LiFi is coming out of previous niche applications just recently covering business applications first, maybe followed by a significant customer market.

Long-range OWC systems comprise fixed and tracked/directed free-space optical (FSO) links e.g., between buildings/towers and in space, both space-to-space and space-to-ground. Different applications impose different requirements in terms of pointing and tracking, and immunity to atmospheric effects.

The workshop will include speakers representing a broad range of LiFi and FSO applications during two sessions. A panel follows each session, so that the audience can contribute, too.

1st session: LiFi
2nd session (FSO terrestrial and space)

Speakers:

Session One: LiFi

Gee-Kung Chang, *Georgia Tech, USA*
Talk Title: Key Enabling Technologies for Post 5G

Harald Haas, Univ. Strathclyde, U.K.
Talk Title: Tbit/s Optical Wireless for Beyond 5G

Ton Koonen, TU Eindhoven, Netherlands
Talk Title: From Wide Beams to Personalized Narrow Ones: Components, Systems and Potential

Kai Lennert Bober, Fraunhofer HHI, Germany
Talk Title: LiFi from the System Point of View

Jean-Paul Linnartz, Signify/Philips Research, Netherlands
Talk Title: Rolling out LiFi: Translating User Experiences into Research Challenges

Session Two: FSO

Baris I. Erkmen, X, USA
Talk Title: Free Space Optical Communications for Terrestrial Applications

Morio Toyoshima, NICT, Japan
Talk Title: Outlook for Satellite Communication Using Free Space Optics

Hamid Hemmati, ViaSat, USA
Talk Title: High-Rate Optical Feederlink to GEO Satellites

Joachim Horwath, Mynaric, Germany
Talk Title: Cost Efficient LEO-optical Inter-satellite Links: Overcoming the Challenges

Katherine Newell, Applied Physics Laboratory, Johns Hopkins University, USA
Talk Title: FSO System Considerations at Sea

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Is Photonics Integration Ready for Next-Generation Optical Access Demands?

Sunday, June 6, 2021
8:00 AM - 10:30 AM

Organizer:

Paola Parolari, *Politecnico di Milano, Italy*
Erman Timurdogan, *Analog Photonics, USA*
Dora Van Veen, *Nokia Bell Labs, USA*

Description:

Due to ever increasing bandwidth demand for services like virtual reality applications, ultra-high definition video, 5G mobile transport and cloud services, the line-rates in optical access systems are continuously pushed higher approaching 100G line-rate. This requires increased complexity in transmission techniques and transceiver systems while maintaining cost-effectiveness as the main objective in these future systems.

Integrated photonics, especially Silicon Photonics, offer lower cost at high volumes than discrete counterparts. So, could photonic integration be the solution to the more complex but still low-cost transceiver technologies needed for next-generation optical access?

Speakers:

Philippe Chanclou, *Orange Labs, France*
Presentation Title: Role of Photonics Integration For TDM(A) and WDM Optical Access

Sezer Erkılınç, *Fraunhofer Heinrich-Hertz-Institute, Germany*
Presentation Title: A Sweet Spot Between DSP or Optics: Complexity Choice In a Monolithically Integrated ONU Transceiver

Christophe Caillaud, *III-V Lab, France*
Presentation Title: Photonic Integration For Optical Access Versus DCI

Francois D. Menard, *AEPONYX Inc., Canada*
Presentation Title: Photonic Integrated Circuits for Cost Effective Higher-end Passive Optical Network Tunable Transceivers

John E. Bowers, *UC Santa Barbara, USA*
Presentation Title: Challenges on Integration of Optical Amplifiers

Leslie Rusch, *Université Laval, Canada*
Presentation Title: Challenges and Opportunities in Scaling SiP to Higher Baud Rates

Robert Blum, *Intel, USA*
Presentation Title: Silicon Photonics based CWDM4 for 5G Applications

Chris Doerr, *Doerr Consulting, USA*
Presentation Title: What Role Can Optical Integration and Associated Packaging Play In The Very-High-Volume and Low-cost Optical-access Market

Peter Ossieur, *IDLab, Ghent University - IMEC, Belgium*
Presentation Title: Technology Options for Dense and Scalable Integration of Photonics and Electronics

Pluggable Coherent Technologies and Applications: Where are We and Where Will We Land in 5 years?

Sunday, June 6, 2021
8:00 AM - 10:30 AM

Organizer:

Antonio Eira, *Infinera, Portugal*
Andreas Matiss, *Corning, Germany*
Xiaoxia Wu, *SpaceX, USA*

Description:

The market for coherent pluggable optics has been evolving rapidly over the past few years from CFP form factor for metro/long-haul applications to various form factors supporting reaches from 10 km to 2000+ km for much broader applications, such as telco metro-access, router-to-router interconnects, point-to-point data center interconnect, mobile and cable aggregation applications. Multiple standardization activities on coherent interfaces have been ongoing, with special emphasis on the 400ZR project at OIF defining a digital coherent interface primarily for DCI applications, which is expected to see large-scale adoption starting in 2021. The application space for coherent pluggables is expanding as well, with the potential to cover scenarios ranging from intra-data center, 5G front/mid/back-haul to free space optical communication etc.

In this workshop, industry experts from network/DC operators, system vendors, and module manufacturers will review recent progress in terms of network deployment requirements/schedule, interoperability, DSP/photonics technology and development status, and share their views of the coherent pluggable technology and applications in the next few years. Some key aspects to be addressed in this workshop include but not limited to the following:

- What are some of the key challenges and perspectives on 800G and beyond low power/cost coherent optics for intra-DC applications?
- What are some of the key aspects and trade-offs of 800G/1.6T ZR?
- Where are the application boundaries for ZR+ type pluggables? How far can it get in long-haul and spectrum-constrained scenarios?
- How far can ZR+ go in trading off performance for footprint? What are the key DSP development design trade-offs concerning power consumption?
- What does pluggable coherent mean for stand-alone transport boxes, and where will pluggable DWDM optics be placed for DC operators and carriers?

Speakers:

The workshop will be divided in two sessions. The first panel is dedicated to discussion on coherent pluggable technology, featuring industry participants involved in the development of new pluggable coherent solutions. The second session will feature speakers from operators and ICPs, which will discuss their vision on coherent pluggable applications over the next few years.

Opening Talk:

Chris Doerr, *Doerr Consulting, USA*

Technology Session:

Wupen Yuen, *Neophotonics, USA*

Eric Manilof, *Ciena, USA*

Osamu Ishida, *NTT, Japan*

Dave Welch, *Infinera, USA*

Applications Session:

Cedric Lam, *Google, USA*

Victor López, *Telefonica, Spain*

Matthew Schmitt, *CableLabs, USA*

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Low Latency Communications — Where Do We Need It? How To Achieve It?

Sunday, June 6, 2021
8:50 AM - 11:20 AM

Organizer:

Michael Freiberger, *Verizon, USA*
Yinying Wang, *Jinan Univ., China*
Benyuan Zhu, *OFS Laboratories, USA*

Description:

Low latency optical fiber communications are essential for emerging time-sensitive applications including but not restricted to 5G x-haul mobile networking, Industrial Internet of Things (IIoT), and modern data centers. This workshop consists of a series of short talks by leading experts from industry and academia, followed by a panel discussion, to address the following two important questions: (1) What are the requirements and technical challenges on low latency for these different time-sensitive applications? (2) What are the enabling technologies, including time-sensitive network architectures and radical solutions such as hollow-core fiber cables?

Speakers:

Nick DelRegno, *Verizon, USA*
Talk Title: 5G Applications Requiring Low Latency

Li Han, *China Mobile, China*
Talk Title: Low Latency Backhaul Technology For 5G

Anurag Khare, *Ciena, USA*
Talk Title: Chipset Impacts on 5G Application Latency

Frank Kschischang, *Univ. of Toronto, Canada*
Talk Title: Zipper Codes For Low-latency Applications

Xiang Liu, *FutureWei, USA*
Talk Title: Time-Sensitive Optical Network Architectures and Technologies For 5G Mobile Networks

Brian Mangan, *OFS Labs, USA*
Talk Title: Hollow-Core-Fiber Cables For Low Latency Fiber Communications

Eric Numkan Fokoua, *Univ. of Southampton, UK*
Talk Title: State-Of-The-Art: Low Loss Wide-Band Hollow-Core Fiber For Low Latency Communications

Joachim Sachs, *Ericsson, Sweden*
Talk Title: Smart Manufacturing Using Low Latency Communications

Xiang Zhou, *Google, USA*
Talk Title: Low Latency For Modern Data Center Applications

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Are We On the Right Track to Bring Co-packaged Optics To Its Prime Time?

Sunday, 06 June 13:00 – 15:30

Organizer:

Xin Chen, *Corning Incorporated, USA*
Zhensheng Jia, *CableLabs, USA*
Di Liang, *Hewlett Packard Enterprise, USA*

Description:

It is widely anticipated that next-gen 51.2 Tb/s switch ASIC will need co-packaged optics (CPO) to tackle the looming challenges in power consumption and bandwidth density. CPO is also promising to flatten current multi-layer switching architecture through a high-radix switch, and enable a large-volume application of fiber to the server (FTTS). This workshop is to stimulate extensive discussions on necessity and challenges to partially/completely replace pluggable solution, and to explore current CPO technology readiness and its future development direction in datacenters and beyond. The workshop will be debating and answering the following three areas:

1. Is CPO a nice-to-have or must-have solution within 3 years? Data center operators and system vendors will discuss their most concerned issues, and the potential applications (e.g., FTTS) CPO can enable or enhance?

2. What are the most recent technology breakthroughs in chip-level building blocks, e.g., SEDES, lasers, VCSEL vs. SiPh, parallel/WDM, DD/coherent, and PICs?

3. What are the progresses in system integration, including packaging, thermal management, optical connectivity, system-level testing and diagnosis, redundancy and serviceability, scalability, signal and power distribution co-design of optical integration with switch/DSP/logic ASIC, and relevant standard development?

Speakers:

Andreas Bechtolsheim, *Arista Networks, USA*
Challenges and Opportunities with Co-packaged Optics

Manish Mehta, *Broadcom, USA*
Co-packaged Optics for Ultra-high Bandwidth Compute and Switching Applications

Mark Filer, *Microsoft, USA*
Opportunities for Co-packaging in Future Microsoft Datacenters

Mark Wade, *Ayar Labs, USA*
Optical I/O Solutions for Next-Generation Communications Fabrics

Joris Van Campenhout, *IMEC, Belgium*
Silicon Photonics Building Blocks for Co-Packaged Optics at 1Tbps/mm and Beyond

Vipul Bhatt, *II-VI Incorporated, USA*
Transceiver Implementation Perspective on Co-packaged Optics

Gordon Keeler, *DARPA, USA*
The DARPA PIPES and LUMOS Programs

Aaron Zikie, *Rockley Photonics, USA*
High Density Silicon Photonics for Co-packaged Optics

Lars Brusberg, *Corning Incorporated, USA*
Optical Connectivity for Co-packaged Optics

Long Chen, *Cisco, USA*
Status of Optoelectronics Multi-chip Modules in Acacia

Darrell Childers, *USConec, USA*
Optical Connector Technology Tradeoffs for Co-Packaged Optics

Peter De Dobbelaere, *Cisco, USA*
Silicon Photonics, the Ideal Technology Platform for Co-packaged Optics Applications

David Hui, *Intel, USA*
Co-Packaged Optical Switch Integration Learnings

Are Wide-band Optical Frequency Comb Capabilities Adequate to Address Evolving Capacity Demands?

Sunday, June 6, 2021
1:00 PM - 3:30 PM

Organizer:

Peter Andrekson, *Chalmers Univ. of Technology, Sweden*
Francesca Parmigiani, *Microsoft, UK*
Ana Pejkic, *Univ. of California San Diego, USA*

Description:

The development of optical frequency combs has largely been driven by applications in metrology and spectroscopy but the promise of hundreds of equidistant coherent optical carriers with high power and SNR should also be attractive in telecommunications as multi-wavelength sources and in optical signal processing. To date, frequency combs have been demonstrated on a number of platforms, with a range of bandwidths and signal integrities. Conventional electro-optical (EO), fiber and chip scale sources have found their way into communications research labs and proposed for numerous telecoms applications. In particular, EO combs have bandwidths ~30 nm, signal integrity and power comparable to standard telecom lasers, and offer excellent stability and controllability making them attractive option in many experiments. Fiber based comb sources have been demonstrated with bandwidths over 200 nm, signal integrity and power comparable to standard telecoms lasers, and used in many large-scale transmission demonstrations. Attempts

to design a chip-scale comb have also been on the rise, with demonstrations that span the C+L band but with signal integrity still short of standard single wavelength sources. Further, there remain concerns about full integration capability and the risk of providing all carriers from a single device. Although comb sources have become commercially available, concerns about their practicality and necessity mean they have yet to carve a niche in modern telecommunications systems. Whilst they potentially offer 100's of high-quality carriers over a large bandwidth, whether there is demand and the capability to meet the power requirements of modulating so many lines remains an open question, as does the impact of photonic integration on the feasibility of their use.

This workshop is organized in three sessions. Session 1 provides an overview of the current status and future trends of optical frequency comb technology. Session II outlines recent research efforts involving optical frequency combs. In Session III industry experts will discuss potential role of optical frequency combs in future systems.

Session 1: Comb Technologies

In this session we will compare different comb technologies and their performance.

- Comb technology overview:
    - Platform, architecture, efficiency, size, complexity, laser integration (on a single chip), power consumption, cost.

- Comb performance:
    - Wavelength range, number of lines, power per line, spectral power uniformity, optical signal to noise ratio, side mode suppression ratio and linewidth (phase noise).
    - Comb reliability, stability, and controllability.
    - Comb performance compared to a single wavelength laser.
    - Key technological challenges
- Which engineering efforts are required to alleviate risk from a single point of failure?
- Potential to improve any aspect discussed above.
    - How will advances in photonics integration affect the performance
- The most suitable application space

Session 2: Comb applications: Research

In this session we will provide an overview of recent research efforts involving optical frequency combs.

- Combs in telecom and datacom communication and processing
    - Large data transmission
    - Comb regeneration
- Combs in secure/quantum communications and processing

- Combs in RF and microwave communications and processing

Session 3: Combs in future systems: Industry perspective

In this session industry experts will discuss potential role of optical frequency combs in future systems.

- Is there a role for frequency combs in modern telecom systems?
    - Can they replace or coexist with single lasers/laser banks?
    - What wavelength range, number of lines, line spacing, power per line, spectral power uniformity, OSNR and linewidth is needed to make them attractive?
    - Which will be decisive factors in their adoption? Performance? Cost? Reliability? Integration with other components? Power dissipation?
    - Which engineering efforts are required to alleviate risk from a single point of failure?
    - Can we exploit the coherence of comb-lines?
    - Can comb regeneration from transmitted seed lasers simplify networks?
    - Which applications and network areas are the most suitable?
    - Is there a role for optical combs in secure/quantum communications and processing?
- Is a chip scale comb a desired alternative to a fiber-based source and a conventional electro-optic comb?
    - If adopted, what requirements do these sources need to meet?
    - Are these technologies likely to coexist? What are the most suitable applications for each technology?
    - How will advances in photonic integration affect the role of frequency combs in telecoms?

Speakers:

Session One Speakers:

Mengjie Yu, *Harvard Univ., USA*
Talk Title: Integrated Lithium-niobate-Based Electro-optic Frequency Combs

Stojan Radic, *UC San Diego, USA*
Talk Title: Fiber-based Optical Frequency Combs: Architecture, Performance, and Key Technological Challenges

Victor Torres, *Chalmers Univ. of Technology, Sweden*
Talk Title: Power Efficient Soliton Microcombs

Tobias Kippenberg, *Swiss Federal Institute of Technology in Lausanne, Switzerland*
Talk Title: On-chip Combs and Laser Integration: Architecture, Performance, and Key Technological Challenges

Session Two Speakers:

Ben Puttnam, *NICT, Japan*
Talk Title: Optical Frequency Combs in Highly-Parallelized SDM/WDM Transmission Experiments

Bill Corcoran, *Monash Univ., Australia*
Talk Title: High-capacity Communications Using Microcombs: Status and Future Prospects

Mikael Mazur, *Nokia Bell Labs, USA*
Talk Title: Comb-based Superchannels: Features and Possible Applications

Session Three Speakers:

John E. Bowers, *AIM Photonics, USA*
Talk Title: Injection Locked, Integrated Resonators for Hertz Level Linewidth Combs

Robert Maher, *Infinera, USA*
Talk Title: Industry Perspective on Comb Adoption Systems

Maxim Bolshtyansky, *SubCom, USA*
Talk Title: Optical Frequency Combs: Submarine Systems Perspective

Sponsored by:

Which Device Technologies Will Get Us Beyond 400G?

Sunday, June 6, 2021
5:00 PM - 7:30 PM

Organizer:

Theodor Kupfer, *Cisco Systems, USA*
Hai-Feng Liu, *HG Genuine, China*
Reza Motaghian, *Amazon, USA*

Description:

The exponential growth of data center traffic continues to push for higher interconnection data rates to reduce the cost/bit and energy/bit. Today, 400GBASE-DR4/FR4 and 400-ZR pluggable optical modules have already begun their

deployment in intra and inter data center networks. As the next development target, 800 GbE and 1.6 TbE are under serious consideration, for which a number of optical technologies have been investigated as the potential candidates.

This workshop will discuss different optical device technologies that can be the potential candidates for 200Gbps/lane in parallel and WDM short reach 800G IMDD systems and single carrier 600-800G coherent systems, which include, but not limited to, high speed EML and DML/DMT, high speed modulators based on SiPh, InP, thin film LiNbO3, and plasmonic, etc. In addition, it will also look into the pros and cons of co-packaged optics using different architectures and optical technologies in comparison with pluggable optics and debate co-packaged optics deployment timelines and volume as well as potential platform interoperability challenges.

The workshop aims to provide a forum for speakers and audience to discuss and compare the achievable performance by different device technologies and technical challenges ahead as the potential solutions for both post 400G IMDD and coherent systems in terms of cost/form factor/power consumption/thermal stability/interoperability relative to current 400G products.

Speakers:

Andy Bechtolsheim, *Arista Networks, USA*
Talk Title: Perspectives on 800G Systems

Xinlun Cai, *Univ. Sun Yat-sen, China*
Talk Title: 200G PAM4 Based on Thin Film Lithium Niobate Modulators

Michael Hockberg, *Elenion/Nokia, USA*
Talk Title: Silicon Photonics Beyond 400G for Intra-datacenter to Intercontinental Reaches

Hong Liu, *Google, USA*
Talk Title: 200G Per Lane For 800G And Beyond

Ken Jackson, *Sumitomo, USA*
Talk Title: Lasers and Detectors For 100Gbd IM-DD Optical Interconnect Applications

Yasuhiro Matsui*, II-VI, USA*
Talk Title: Isolator-Free Low-Chirp DML for > 200Gb Applications

Radha Nagarajan, *Inphi, USA*
Talk Title: 800G Options for Inter and Intra Data Center Applications

Yoshihiro Ogiso, *NTT, Japan*
Talk Title: InP MZ/IQ Modulator Beyond 130Gbaud

Dave Plant, *Uni. McGill, Canada*
Talk Title: Silicon Photonic Modulators for High Speed Data Center Interconnects

Georg Roell, *Ranovus, Canada*
Talk Title: 51.2T/100T Switch/Co-Packed Optics and SIP Solution Beyond 400G

Ashkan Seyedi, *HPE, USA*
Talk Title: 800G For Pluggable and 1.2T and 3.2T Co-Packaged Silicon Photonics

Shigehisa Tanaka*, Lumentum, Japan*
Talk Title: EA-DFB and DML Technologies For Post 400gbe Applications

Winston Way, *NeoPhotonics, USA*
Talk Title: A Cost-Effective Intra-Data Center 800G Coherent Transceiver Solution

Shogo Yamanaka, *NTT, Japan*
Talk Title: SiPh Coherent Optical Subassembly Beyond 100 Gbaud

Sponsored by:

Panels

The panels provide an interactive learning environment and are open to all conference registrants. Similar to invited and tutorial speakers, panel topics and organizers are chosen through a highly selective nominations process.

All times are Pacific Daylight Time (UTC-07:00)

Deployment Challenges of 400G Optics and Beyond

Monday, June 7, 2021
1:00 PM - 3:00 PM

Organizer:

Friedel Gerfers, *Technische Universität Berlin, Germany*
Zuowei Shen, *Google, USA*
Liang Zhang, *Huawei Technologies, Germany*

Description:

Hyperscale data centers are now deploying 400G optics for the new generation of networks after several years of innovations and development in the enabling technologies. 400G is an inflection point for the industry to switch from NRZ modulation to PAM4. PAM4 modulation poses more challenges to optical components, optical & electrical channels, SerDes and DSP to ensure reliable performance at scale.

The panelists will share their view of the major deployment challenges in 400G optics and beyond. What interoperability issues are found in early deployment (e.g. optical technologies, DSP), What are the challenges in system integration qualification to ensure robust link, What are new in field deployment compared to 100G-NRZ optics, What are the benefits of real time link health diagnostic unit, What could be added to IEEE/MSA to improve interoperability at 800G?

Speakers:

Andy Bechtolsheim, *Arista Networks, USA*
Presentation Title: To be determined

Loi Nguyen, *Marvell, USA*
Presentation Title: Disruptive DSP Technology Enables Deployment of 400G Optics and Beyond

Osa Mok, *Innolight Technology, USA*
Presentation Title: Deployment Challenges of 400G Optics and Beyond

Jian Wang, *Tencent, China*
Presentation Title: Challenges and Path Into Beyond 400G Optics

THz Communication for Beyond 5G Networks

Tuesday, June 8, 2021
3:00 AM - 5:00 AM

Organizer:

Mohamed-Slim "Slim" Alouini, *King Abdullah Univ. of Science & Tech (KAUST), Saudia Arabia*
Yikai Su, *Shanghai Jiao Tong Univ., China*

Description:

Terahertz (THz)-band communications are a key enabler for future-generation wireless communication systems that promise to integrate a wide range of data-demanding and delay-sensitive applications. Recent advancements in electronic, photonic, and plasmonic technologies are closing the gap in THz transceiver design. Consequently, prospect THz signal generation, modulation, and radiation methods are converging, and the corresponding channel model, noise, and hardware-impairment notions are emerging. These advancements pave the way to well grounded research directions on THz-specific signal processing and communication techniques for wireless communications. In this context, this panel aims to go over the opportunities and challenges of communication systems operating in the THz band. It further motivates novel signal processing and communication techniques for MIMO-enabled THz sensing, as well as THz indoor localization.

Speakers:

Xianbin Yu, *Zhejiang Univ., USA*
Presentation Title: Photonics-enabled Ultrafast THz Communications

Akifumi Kasamatsu, *National Institute of Information and Communications Technology (NICT), Japan*
Presentation Title: Development Activities For 300-Ghz Band Transceivers with Electronic Approach

Jianping Yao, *Univ. of Ottawa, Canada*
Presentation Title: Role of Silicon Photonics in Microwave Photonics

Josep M Jornet, *Northeastern Univ., USA*
Presentation Title: Conquering the Spectrum: Ultra-broadband Physical and Link Layer Solutions

Challenges of Coherent Transponders Approaching the Shannon Limit

Tuesday, June 8, 2021
2:00 PM - 4:00 PM

Organizer:

Steve Grubb, *Facebook, USA*
Priyanth Mehta, *Ciena, USA*
Georg Mohs, *Subcom, USA*

Description:

This panel will discuss the value of field trials with modern transponders.

Key questions for debate are:

- How close will we be able to approach Shannon limit in the field?
- Will field trials be needed or can we characterize transponder performance sufficiently in the lab to predict performance in the field?
- What is an acceptable gap between lab results and field trials?
- Can we use offline processing to reliably demonstrate the capability of next generation technology or are the uncertainties too great?
- What are the parameters in the field that should be controlled in order to allow us to get closer to the Shannon Limit?
- Can DSP help to relax some of the requirements on these parameters?

The panelists will cover a broad range of perspectives from suppliers to users for a lively discussion.

Speakers:

Andreas Leven, *Nokia, Germany*

Kim Papakos, *Windstream, USA*

Kim Roberts, *Ciena, Canada*

Pierre Mertz, *Infinera, USA*

Liz Rivera-Hartling, *Facebook, USA*

Christian Rasmussen, *Acacia, USA*

Mattia Cantono, *Google, USA*

PON Disaggregation, from SDN Abstraction to Full Virtualization. Benefits, Obstacles and Trends

Thursday, June 10, 2021
12:30 PM - 2:30 PM

Organizer:

Luiz Anet Neto, *IMT Atlantique, France*
Daniel Kilper, *Univ. of Arizona, USA*
Marco Ruffini, *Trinity College, Ireland*

Description:

Access network virtualization is an area that has recently grown in popularity, thanks to its promise to deliver a disaggregated and open architecture that can increase flexibility, minimize cost of ownership and open up the telecom market to a multitude of new vendors.

While the topic extends to a wide range of domains, including mobile and fixed networks, data centres and edge clouds, this panel session will focus on the latest developments in optical access virtualization, delving into a number of key questions around the virtualization of Passive Optical Networks (PONs).

After positioning PON virtualization within the broader context of next generation and disaggregated networks, panel members from telecoms operators, vendors and academia will discuss topics such as current and future use cases and benefits of PON virtualization; architectures and performance of virtualized PON systems; trade-offs between high-level SDN abstraction and deep PON virtualization; and roadmaps for implementing a disaggregated PON in production networks.

Speakers:

Kota Asaka, *NTT, Japan*
Talk Title: Use Cases and Benefits of PON Virtualization

Mike O'Hanlon, *Intel, USA*
Talk Title: Towards a Generic Access Architecture – A PON Virtualization Study

Philippe Chanclou, *Orange, France*
Talk Title: Promises of Software Defined Access Networks and PON Virtualization

Micheal Freiberger, *Verizon, USA*
Talk Title: Digital Twin: How Every Operator Should Have an Extra Access Network

Aki Nakao, *Tokyo Univ., Japan*

Advanced Laser Technologies in Post-100Gbaud Era

Thursday, June 10, 2021
3:00 PM - 5:00 PM

Organizer:

Geert Morthier, *Ghent Univ. – IMEC, Belgium*
Hideyuki Nasu, *Furukawa, Japan*
Hanxing Shi, *Liturex, USA*

Description:

In this panel, we will have several semiconductor laser experts to intensively present and discuss about their visions on various advanced laser technologies feasible in the post-100Gbaud era, in telecom, datacom, and data center applications.

Directly modulated lasers (DMLs) are attractive to generate high speed optical signals with low power. Several remarkable results of expanded modulation bandwidth recently have been reported on edge-emitters using very specific approaches. We will discuss if these approaches are suitable to practical systems or if there is any barrier to prevent the actual deployment, including operation robustness, reliability, yield, signal integrity, and cost. We also need to discuss the possibilities of adopting these technologies to future VCSELs targeting short-reach applications.

On the other hand, CW lasers (CWLs) integrated with an external modulator has been widely used for Data Center Interconnects (DCIs) and telecom applications. The CW-WDM MSA was established recently to define and promote specifications for multi-wavelength advanced integrated optics for DCIs and telecom applications. We would like to understand the scope of the MSA, and the latest updates, requirements and potential challenges to the CWL deployments. Hybrid integration of a CWL onto a Photonic Integrated Circuit (PIC) has been demonstrated as well as an external laser source for a PIC, but we would like to scrutinize both advantages and disadvantages of each approach.

For long reach telecom systems, narrow-linewidth wavelength-stabilized tunable lasers have been used with digital coherent technologies. The mechanical sizes of optical modules and sub-assemblies have been shrinking and accordingly smaller packaged tunable lasers have been demanded. We want to discuss the capabilities of narrower linewidth, higher output power, lower noise, and lower power consumption for tunable

lasers. We will also discuss how to realize smaller packaged tunable lasers for manufacturing.

Speakers:

Shinji Matsuo, *NTT, Japan*
Presentation Title: Directly Modulated Membrane Laser with 100-Gbaud Operation and Its Capability of WDM Transmitter PIC

Yasuhiro Matsui, *II-VI, USA*
Presentation Title: Isolator-Free Low-Chirp Directly Modulated Laser for 400Gb Transmission

Dieter Bimberg, *TU Berlin, Germany*
Presentation Title: Novel VCSEL Designs Integratable to Energy-Efficient Drivers Enabling Low Series Resistance High Power Fundamental Mode Emission for 100+ GBaud

John Johnson, *Broadcom Inc., USA*
Presentation Title: Advanced CW Lasers for Silicon Photonic Applications

Jing Zhang, *Ghent Univ.-Imec, Belgium*
Presentation Title: III-V on Si Integrated Lasers and PICs Realized Using Micro-Transfer Printing

Kazuya Nagashima, *Furukawa Electric, Japan*
Presentation Title: Narrow-Linewidth Wavelength-Tunable Lasers and Their Packaging Technologies

Pros and Cons of Low-margin Optical Networks

Thursday, 10 June
15:00 - 17:00

Organizers: Martin Birk, Curbius, USA; Yvan Pointurier, Huawei, France; Jane M. Simmons, Monarch Network Architects, USA; Sorin Tibuleac, ADVA Optical Networking, USA

Is Optical Switching Finally Ready For Large-scale Deployment in Datacenters and Advanced Networks?

Friday, 11 June 10:30 – 12:30

Organizer:

Hideaki Furukawa, *National Institute of Information and Communications Technology (NICT), Japan*
Kazuhiro Ikeda, *National Institute of Advanced Industrial Science and Technology (AIST), Japan*
Richard Jensen, *H+S Polatis Inc., USA*

Description:

Optical switching technologies have been steadily advancing in recent years and are being deployed in an ever growing range of networks. Optical switching technologies are attractive due to their data transparency, low-latency and energy efficiency. Emerging applications that could lead to wide scale deployment include scale-out datacenters, optical access networks, space communications, optical sensing, and high-performance computing. Data centers operators in particular see a never-ending growth in demand for high bandwidth reconfigurable services, and are considering the potential of optical switching to provide software-defined virtual connectivity and also to lower costs by increasing utilization and power efficiency through resource disaggregation.

In this panel we will cover recent advances in optical switching technology and development roadmaps along with the driving forces behind current and emerging applications in datacenters and other fields. We will address the key question as to whether optical switching technologies are finally ready for large scale deployments.

Key Topics and Questions to Cover:

1. Current and emerging optical switching applications
2. Driving forces behind deployment of optical switching in networks and datacenters
3. When will optical switches be widely deployed in datacenters and what barriers to entry remain?
4. Where will optical switching technology be in 5 and 10 years?
5. Are very large 10K x 10K optical switches with nanosecond switching speeds really needed?

Speakers:

Hitesh Ballani, *Microsoft Research, UK*
Data-center networking for a post-Moore's Law Era

Ken-ichi Sato, *Nagoya Univ. and AIST, Japan*
Innovating Intra Data Center Networks with Large-scale Optical Switches - Technologies and Performance Achieved

George Porter, *Univ. of California, San Diego, USA*
Control Planes for Optical Switching

Nick Parsons, *H+S Polatis, UK*
High Radix Optical Switching: Ready for Prime Time?

Benjamin G. Lee, *NVIDIA Research, USA*
Photonic Switch Modules Offering Fast and Efficient Reconfigurability

Tae Joon Seok, *nEYE Systems, USA*
Large-scale Silicon Photonic Switches with Integrated MEMS

Symposia and Special Sessions

Symposia

Emerging Photonic Technologies and Architectures for Femtojoule per Bit Optical Networks

Organizers: Dan Blumenthal, *University of California, Santa Barbara, USA*; Argishti Melikyan, *Nokia Bell Labs, USA*; Oleg Sinkin, *TE Subcom, USA*

On the Edge: MEC- based Network Architectures in Support of Enterprise Cloud

Organizers: Dimitra Simeonidou, *University of Bristol, UK*; Reza Nejabati, *University of Bristol, UK*; Elaine Wong, *The University of Melbourne, Australia;* Yawei Yin, *Microsoft Corp., USA*

Quantum Information Science and Technology (QIST) in the Context of Optical Communications

Organizers: Michela Svaluto Moreolo, *CTTC, Spain*; Eleni Diamanti, *CNRS, France*; Ivan Djordjevic, *University of Arizona, USA;* Helmut Griesser, *ADVA, Germany;* Dominic O'Brien, *University of Oxford, UK*

Description:

Quantum Information Science and Technology (QIST) covers such fields as quantum communications, quantum computing or simulation as well as quantum sensing. Photonics plays a major role in QIST hardware and systems, and basic concepts from optical communications and information processing underpin many experiments and applications of QIST.

The promises of quantum technologies are impressive, but huge are also the challenges to understand and realize practical and reliable devices and systems. Major collaborative efforts around the world like the Quantum Flagship in Europe and the U.S. National Quantum Initiative are pushing research and early applications of quantum technologies. More specifically on quantum communication, China is getting a lot of attention for the Micius satellite and Europe is launching a Quantum Communication Infrastructure (EuroQCI) initiative.

In the symposium, we will discuss different aspects of QIST under the light of their relevance for optical communications. For quantum key distribution (QKD), which is one of the most mature applications, the focus is on the integration into a communications environment, the operator perspective and deployment experiences. We also look into the technological progress and future developments for QKD.

The second part of the symposium addresses the challenges for realizing full-scale quantum networks and the advanced applications such a network can support, like connecting quantum computers or sensors. In addition we discuss the role integrated quantum optics can play for photonic quantum computing.

The Role of Machine Learning in Optical Systems and the Role of Optics in Machine Learning Systems

Organizer: S. J. Ben Yoo, *University of California, Davis, USA;* Manya Ghobadi, *MIT, USA*

Description:

This symposium explores optics, machine learning, and AI techniques for next-generation data centers and networking systems, both in terms of leveraging ML techniques for optical systems (ML for optics) and optical technologies for ML workloads (optics for ML) and their impacts, and use cases. In this Symposium, large-scale network operators, ML/AI experts, virtualization researchers, and technology researchers will discuss (a) the role of machine learning and AI techniques to effectively control, manage, and plan next-generation data centers, high-performance clusters, and communication networks, and (b) the role of emerging optical technologies in enabling disaggregated ML systems, next-generation ML/AI architectures, application-driven reconfiguration, neuromorphic computing. The Symposium will include a panel discussion on emerging photonic and photonic-electronic systems for efficiently and effectively accelerating ML training and inference workloads.

Special Sessions

Vision Talks: Beyond 2021 and Towards 2030

Monday, June 7, 2021
5:00 AM - 9:30 AM

Organizer: *Ramon Casellas, CTTC, Spain; Chris Cole, II-IV Incorporated, USA; Ming-Jun Li, Corning, USA*

Description:

After 50 years of successful developments in optical fiber, component, transmission and networking technologies, optical fiber communications have changed world by providing enormous bandwidth and low latency for applications, ranging from global backbone internet networks to the massively parallel interconnects inside datacenters.

Nevertheless, the field of optical fiber communications is still a diverse and rapidly changing one, where new technologies and innovations are anticipated to meet the ever-increasing demands for higher capacity, lower cost, and lower energy consumption.

Looking forward to the next decade, this special session gets industry experts together to share their visions for optical fiber communications in the next decade and discuss the emerging hot topics and groundbreaking innovations.

Speakers:

Session I
Gordon Keeler, DARPA, USA
Optical Microsystem Technologies and Applications

Aneek James, Columbia University, USA
Diversity, Equity, and Inclusion in the Optics Industry in 2030

Anuj Jain, Reliance Jio InfoCom, India
Title to be Announced

Claudio Mazzali, Corning Research & Development Corp, USA
Shepherding Bits and Photons during the Next Decade

Session II
Kithinji Muriungi, KamsHub, Kenya
Photonics Vision 2030 in Africa

Vijay Vusirikala, Google LLC, USA
Optical Networking Long Term Vision: A Hyperscaler Perspective

Andrew Lord, BT Applied Research, UK
Future Optical Networks in a 10 Year Time Frame

Henning Lysdal, NVIDIA, Denmark
Optical Communication in the age of AI

Peter Winzer, Nubis Communications, USA
Capacity Scaling Through Spatial Parallelism: From Subsea Cables to Short-reach Optical Links

Lessons Learned: Networks 2020 Status and Next Steps

Organizers: Steve Grubb, *Facebook, USA;* Loukas Paraschis, *Infinera, USA*

Sunday, 06 June

3:00 - 7:00 Pacific Time (US & Canada) (UTC - 07:00)

SC369

Short Course - SC369 -Test and Measurement for Signals with Complex Optical Modulation

SC452

Short Course - SC452 - FPGA Programming for Optical Subsystem Prototyping

SC463

Short Course - SC463 - Optical Transport SDN: Architectures, Applications and Actual Implementations

4:00 - 7:00 Pacific Time (US & Canada) (UTC - 07:00)

SC470

Short Course - SC470 - Secure Optical Communications

5:00 - 7:30 Pacific Time (US & Canada) (UTC - 07:00)

S1A

Special Event - Workshop: Will Multiband, Multidimensional, SDM Effectively Address the Need for Increased Network Capacity?

S1B

Special Event - Workshop: Optical Signal Processing: Neuromorphic Computing and Quantum Information Processing?

S1C

Special Event - Workshop: Cognitive Network Automation: How Smart Can Optical Transport Networks Be?

8:00 - 10:30 Pacific Time (US & Canada) (UTC - 07:00)

S2A

Special Event - Workshop: Pluggable Coherent Technologies and Applications: Where Will We Land in 5 Years?

S2B

Special Event - Workshop: Low Latency Communications — Where Do We Need It? How To Achieve It?

S2C

Special Event - Workshop: Optical Wireless Communications: What is Stopping Us?

S2D

Special Event - Workshop: Is Photonics Integration Ready for Next-generation Optical Access Demands?

8:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

SC105

Short Course - SC105 - Modulation Formats and Receiver Concepts for Optical Transmission Systems

SC203

Short Course - SC203 - 400 Gb/s and Beyond Optical Communication Systems, Design and Design Trade-offs

SC208

Short Course - SC208 - Optical Fiber Design for Telecommunications and Specialty Applications

SC390

Short Course - SC390 - Introduction to Forward Error Correction

SC395

Short Course - SC395 - Modeling and Simulation of Optical Transmitter and Receiver Components for Coherent Communications

SC461

Short Course - SC461 - High-capacity Data Center Interconnects for Cloud-scale Networking

9:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

SC433

Short Course - SC433 - Introduction to Photodetectors and Optical Receivers

SC460

Short Course - SC460 - Digital Coherent Optical System Performance Basics

11:00 - 13:00 Pacific Time (US & Canada) (UTC - 07:00)

S3Z

Special Event - Lab Automation Hackathon

13:00 - 15:30 Pacific Time (US & Canada) (UTC - 07:00)

S3A

Special Event - Workshop: Are We on the Right Track to Bring Co-packaged Optics to Its Prime Time?

S3B

Special Event - Workshop: Are Wide-band Optical Frequency Comb Capabilities Adequate to Address Evolving Capacity Demands?

13:00 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

SC267

Short Course - SC267 - Silicon Microphotonics: Technology Elements and the Roadmap to Implementation

SC384

Short Course - SC384 - Background Concepts of Optical Communication Systems

14:00 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

SC205

Short Course - SC205 - Integrated Electronic Circuits for Fiber Optics

SC444

Short Course - SC444 - Optical Communication Technologies for 5G

SC484

Short Course - SC484 - Transport Evolution Due to Cloud Services and Network Resiliency

SC485

Short Course - SC485 - Advanced Fiber Access Networks

17:00 - 19:30 Pacific Time (US & Canada) (UTC - 07:00)

S4A

Special Event - Workshop: Which Device Technologies Will Get Us Beyond 400G?

17:00 - 21:00 Pacific Time (US & Canada) (UTC - 07:00)

SC469

Short Course - SC469 - Hands-on: Laboratory Automation and Control using Python

18:00 - 21:00 Pacific Time (US & Canada) (UTC - 07:00)

SC177

Short Course - SC177 - High-Speed Semiconductor Lasers and Modulators

SC428

Short Course - SC428 - Link Design and Modeling for Intra Data Center Optical Interconnects

SC459

Short Course - SC459 - Multimode Photonic Devices, Characterization and Applications

Monday, 07 June

3:00 - 7:00 Pacific Time (US & Canada) (UTC - 07:00)

SC341

Short Course - SC341 - Sub-carrier Modulation and Superchannels for Terabit-class DWDM Transceivers

SC393

Short Course - SC393 - Digital Signal Processing for Coherent Optical Transceivers

SC448

Short Course - SC448 - Software Defined Networking for Optical Networks: a Practical Introduction

SC454

Short Course - SC454 - Hands-on: Introduction to Silicon Photonics circuit design

SC468

Short Course - SC468 - Advanced FEC Techniques for Optical Communications

SC483

Short Course - SC483 - Machine Learning in Optical Networks

3:30 - 4:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC1

Exhibit Hall Event - Technology Showcase: Creating Scalable and Flexible Future-Proof Networks with Programmable Optical System-on-Chip

3:30 - 5:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

4:00 - 7:00 Pacific Time (US & Canada) (UTC - 07:00)

SC447

Short Course - SC447 - The Life Cycle of an Optical Network: From Planning to Decommissioning

SC450

Short Course - SC450 - Design, Manufacturing, and Packaging of Opto-Electronic Modules

4:30 - 5:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC2

Exhibit Hall Event - Technology Showcase: Innovative Use of 400G ZR+ Reshapes Optical Network Economics

5:00 - 7:00 Pacific Time (US & Canada) (UTC - 07:00)

M1A

Special Session: Vision Talks: Beyond 2021 and Towards 2030 (Part 1)

Presider: Christopher Cole

M1A.1

Optical Microsystem Technologies and Applications

Invited

Presenter: Gordon Keeler , *DARPA*

Rapid innovation in photonic-electronic integration promises to deliver transformative capabilities beyond the data center. This talk describes DARPA programs advancing optical microsystem technologies for emerging applications including computing, sensing, quantum systems, and precision frequency control.

Authors:Gordon Keeler, DARPA

M1A.2

Diversity, Equity, and Inclusion in the Optics Industry in 2030

Invited

Presenter: Aneek James , *Columbia University*

Continued growth of the optics industry demands a diverse workforce of researchers, scientists, and engineers. In this talk, recommendations are made for developing a workforce that can drive innovation over the next decade and beyond.

Authors:Aneek James, Columbia University

M1A.3

Optical Networking Long Term Vision: a Hyperscaler Perspective

Invited

Presenter: Vijay Vusirikala , *Google LLC*

Abstract not available.

Authors:Vijay Vusirikala, Google LLC

M1A.4

Shepherding Bits and Photons During the Next Decade

Invited

Presenter: Claudio Mazzali , *Corning Optical Communications*

We will discuss the fndamental challengs of energy, coupling, photon management and integration that our comunity will face during the next decade as we contiue to build the optical fabric that sustains our modern society

Authors:Claudio Mazzali, Corning Optical Communications

M1B

OFC Demo Zone (Part 1)

Presider: Liang Du

M1B.1

Demonstration of an SDN-Enabled VCSEL-Based Photonic System for Spectral/Spatial Connectivity in Disaggregated Optical Metro Networks

Presenter: Michela Svaluto Moreolo , *Ctr Tecnològic de Telecom de Catalunya*

This demo showcases an SDN control platform configuring VCSEL-based photonic transceiver and white-box nodes for end-to-end programmability in disaggregated optical metro networks also including the spatial dimension with a polymer switch and 25km 19-core MCF.

Authors:Michela Svaluto Moreolo, Ctr Tecnològic de Telecom de Catalunya / Ricardo Martínez, Ctr Tecnològic de Telecom de Catalunya / Josep Maria Fabrega, Ctr Tecnològic de Telecom de Catalunya / Ramon Casellas, Ctr Tecnològic de Telecom de Catalunya / Javier Vílchez, Ctr Tecnològic de Telecom de Catalunya / Laia Nadal, Ctr Tecnològic de Telecom de Catalunya / Ricard Vilalta, Ctr Tecnològic de Telecom de Catalunya / Raul Muñoz, Ctr Tecnològic de Telecom de Catalunya / Christian Neumeyr, Vertilas GmbH / Hyun-Do Jung, Electronics and Telecommunications Research Institute (ETRI) / Jang-Uk Shin, Electronics and Telecommunications Research Institute (ETRI) / Alberto Gatto, Politecnico di Milano / Paola Parolari, Politecnico di Milano / Pierpaolo Boffi, Politecnico di Milano / David Larrabeiti, Universidad Carlos III de Madrid / Juan-Pedro Fernández-Palacios, Telefonica Global CTO

M1B.2

Operationalizing Partially Disaggregated Optical Networks: an Open Standards-Driven Multi-Vendor Demonstration

Presenter: Esther Le Rouzic , *Orange Labs*

We present and demonstrate service provisioning in partially disaggregated multi-vendor network automation scenarios with online physical impairment validation. This work uses and extends standard interfaces (OpenConfig and ONF Transport API) to retrieve network information interacting with TIP GNPy tool.

Authors:Esther Le Rouzic, Orange Labs / Anders Lindgren, Telia / Stefan Melin, Telia / Denise Provencher, Fujitsu / Raghavan Subramanian, Fujitsu / Roshan Joyce, Fujitsu / Francois Moore, Fujitsu / Dwayne Reeves, Fujitsu / Antonio Rambaldi, ADVA / Pawel Kaczmarek, ADVA / Kevin Weeks, ADVA / Gaurav Agrawal, IP Infusion / Srikanth Krishnamoha, IP Infusion / Bartek Raszczyk, EdgeCore / Tomas Uhlar, CESNET / Ramon Casellas, CTTC / Oscar Gonzalez de dios, Telefonica R&D / Victor López, Telefonica R&D

M1B.3

A Non-Proprietary Network Operations Platform for OpenROADM Environment

Presenter: Nathan Ellsworth , *The University of Texas at Dallas*

Key functionalities of NOP (Network Operations Platform) are demonstrated with the latest multi-vendor OpenROADM equipment.
Using open source packages, the NOP inter-operates with TransportPCE and other controllers, bringing together information about topology, events, and metrics.

Authors:Nathan Ellsworth, The University of Texas at Dallas / Behzad Mirkhanzadeh, The University of Texas at Dallas / Tianliang Zhang, The University of Texas at Dallas / Shweta Vachhani, AT&T Labs / Balagangadhar Bathula, AT&T Labs / Gilles Thouenon, Orange Labs / Christophe Betoule, Orange Labs / Olivier Renais, Orange Labs / Miguel Razo, The University of Texas at Dallas / Andrea Fumagalli, The University of Texas at Dallas

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M1B.4

Demonstration of Extensible Disaggregated NE Management Based on a SONiC-Compliant Software-Agent Optical OpenConfig/GNMI Telemetry Go Implementation.

Presenter: Abhinava Sadasivarao , *Infinera Corporation*

The proof-of-concept of a robust and extensible disaggregated network element management using a SONiC-complaint Go-based software agent implementation of OpenConfig gNMI optical streaming telemetry, is demonstrated and evaluated in a multivendor testbed.

Authors:Abhinava Sadasivarao, Infinera Corporation / Yawei Yin, Microsoft Corporation / Karthikeyan Balasubramanian, Microsoft Corporation / Ryan Morgan, Microsoft Corporation / Paulo Gomes, Infinera Corporation / Sharfuddin Syed, Infinera Corporation / Loukas Paraschis, Infinera Corporation

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M1B.5

Scalable for Cloud-Native Transport SDNController Using GNPy and Machine Learningtechniques for QoT Estimation

Presenter: Carlos Manso , *CTTC*

This demo shows a cloud-native SDN controller that can estimate end-to-end QoT using both analytical (GNPy) and machine learning algorithms on WDM systems. This transport SDN controller is able to scale horizontally using custom metrics.

Authors:Carlos Manso, CTTC / Ricard Vilalta, CTTC / Raul Muñoz, CTTC / Ramon Casellas, CTTC / Ricardo Martínez, CTTC

M1B.6

GNPy & YANG: Open APIs for End-to-End Service Provisioning in Optical Networks

Presenter: Jan Kundrát , *CESNET*

We demonstrate end-to-end service provisioning in a fully disaggregated optical network using open software interfaces.
The GNPy quality-of-transmission estimator is extended with a YANG-based API.
The YANG modeling work builds on the IETF standard schemas, and describes multiple layers of the network at once.

Authors:Jan Kundrát, CESNET / Esther Le Rouzic, Orange / Jonas Mårtensson, RI.SE / Andrea Campanella, Open Networking Foundation / Ondrej Havliš, CESNET / Andrea D'Amico, POLITO / Gert Grammel, Juniper / Gabriele Galimberti, Cisco / Vittorio Curri, POLITO / Josef Vojtech, CESNET

M1B.7

All-Indoor Optical Customer Premises Equipment for Fixed Wireless Access

Presenter: Dominic Schulz , *Fraunhofer Heinrich Hertz Institute*

We demonstrate an LED-based optical wireless link for fixed wireless access applications, at data rates of 1.5 Gbit/s over 50 m. Transmission between indoor equipment and outdoor access point is possible through metal-coated insulation glass.

Authors:Dominic Schulz, Fraunhofer Heinrich Hertz Institute / Julian Hohmann, Fraunhofer Heinrich Hertz Institute / Peter Hellwig, Fraunhofer Heinrich Hertz Institute / Christoph Kottke, Fraunhofer Heinrich Hertz Institute / Ronald Freund, Fraunhofer Heinrich Hertz Institute / Volker Jungnickel, Fraunhofer Heinrich Hertz Institute / Ralf-Peter Braun, Deutsche Telekom AG / Frank Geilhardt, Deutsche Telekom AG

M1B.8

High Precision Indoor Robot Localization Using VLC Enabled Smart Lighting

Presenter: Yiru Wang , *The Hong Kong University of Science and Technology*

A high precision visible light communication (VLC)-based mobile robot positioning demonstration is proposed. Based on our built experiment platform, the positioning accuracy is within 2cm.

Authors:Yiru Wang, The Hong Kong University of Science and Technology / weipeng guan, The Hong Kong University of Science and Technology / Babar Hussain, The Hong Kong University of Science and Technology / Patrick Yue, The Hong Kong University of Science and Technology

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M1B.9

Li-Poster: Real-Time Non-Line-of-Sight Optical Camera Communication for Hand-Held Smartphone Applications

Presenter: Liqiong Liu , *The Chinese University of Hong Kong*

We demonstrate a real-time flicker-free optical camera communication system that allows retrieval of descriptions from the complex optical signals reflected by an exhibition poster or artwork using a hand-held smartphone.

Authors:Liqiong Liu, The Chinese University of Hong Kong / Lian-Kuan Chen, The Chinese University of Hong Kong

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7:00 - 7:30 Pacific Time (US & Canada) (UTC - 07:00)

Special Event - Demo Zone Demonstrations in Action

7:30 - 9:00 Pacific Time (US & Canada) (UTC - 07:00)

SpE1

Exhibit Hall Event - OFC Career Zone Part One: Career (Re) Start: Elevator Pitch, Resume Tips and Interview Best Practices

7:30 - 9:30 Pacific Time (US & Canada) (UTC - 07:00)

M2A

Special Session: Vision Talks: Beyond 2021 and Towards 2030 (Part 2)

Presider: Christopher Cole

M2A.1

Photonics Vision 2030 in Africa

Invited

Presenter: Kithinji Muriungi , *KamsHub*

Africa holds a rich history that suggests the successful adoption of the fourth industrial revolution driven by photonics. This paper connects the dots and plots or projects how photonics in Africa might be in 2030.

Authors:Kithinji Muriungi, KamsHub / Fidel Makatia, AFECS

M2A.2

Jio 15 Exabyte National Network Enabling Digital India Using Latest Optical Technologies

Invited

Presenter: Anuj Jain , *Reliance Jio InfoCom*

Abstract not available.

Authors:Anuj Jain, Reliance Jio InfoCom

M2A.3

Future Optical Networks in a 10 Year Time Frame

Invited

Presenter: Andrew Lord , *BT Applied Research*

We describe the evolution of the network over a time-scale of 10 years. We cover the merger of photonics and electronics, optical switching, reliance on data-center technologies and architectural evolution.

Authors:Andrew Lord, BT Applied Research / Catherine White, BT Applied Research / Md Asif Iqbal, BT Applied Research

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M2A.4

Optical Communication in the age of AI

Invited

Presenter: Henning Lysdal , *NVIDIA*

AI is software that writes software, and it is fed by data. AI is the most powerful force of our time and it profoundly changes the way computers are built and connected.

Authors:Henning Lysdal, NVIDIA

M2A.5

Capacity Scaling Through Spatial Parallelism: From Subsea Cables to Short-Reach Optical Links

Invited

Presenter: Peter Winzer , *Nubis Communications*

Spatial parallelism is the only way to continue the exponential capacity scaling of optical networks. We discuss trade-offs and implications of spatial parallelism from ultra-long-haul subsea cables and terrestrial mesh networks to short-reach optical links.

Authors:Peter Winzer, Nubis Communications

M2B

OFC Demo Zone (Part 2)

Presider: Nan Chi

M2B.1

A New FOWLP Platform for Hybrid Optical Packaging - Demonstration on 100Gbps Transceiver

Presenter: Seongwook Choi , *Lipac*

The Fan Out Wafer Level Packaging, widely used in the silicon semiconductor system, is introduced for all-in-one hybrid optical package with small form factor, potentially higher performance, and expendability to on-board/co-packaged optical interconnections. To prove the new packaging idea, 100GBASE-SR4 standard is targeted in this demonstration.

Authors:Seongwook Choi, Lipac / Yoonyoung Bae, Lipac / Sukyoon Oh, Lipac / Seungman Han, Lipac / David Dongwoo Park, Lipac / Youngjun Park, Lipac

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M2B.2

RSE-Based Optical Camera Communication in Underwater Scenery With Bubble Degradation

Presenter: Zi Hao Zhou , *South China University of Technology*

Optical camera communication (OCC) is a promising technique.We demonstrated a rolling-shutter-based OCC in the underwater bubble scenario with 7.2 kbit/s data rate by employing the proposed de-bubble algorithm and binary fringe correction.

Authors:Zi Hao Zhou, South China University of Technology / ShangSheng Wen, South China University of Technology / Guan Weipeng, South China University of Technology

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M2B.3

Demonstration of a Dynamic QKD Network Control Using a QKD-Aware SDN Application Over a Programmable Hardware Encryptor

Presenter: Rodrigo Tessinari , *University of Bristol*

We successfully implemented a QKD-Aware SDN application capable of real-time monitoring and controlling a quantum secure network paired with a programmable FPGA encryption/decryption technology to provide on-demand encryption algorithms for network services between different sites.

Authors:Rodrigo Tessinari, University of Bristol / Ekin Arabul, University of Bristol / obada alia, University of Bristol / Abubakar Siddique Muqaddas, University of Bristol / George Kanellos, University of Bristol / Reza Nejabati, University of Bristol / Dimitra Simeonidou, University of Bristol

M2B.4

Demonstration of Software-Defined Key Management for Quantum Key Distribution Network

Presenter: Catherine White , *BT Labs*

We demonstrate a practical key management scheme for a quantum key distribution network. Multi-vendor QKD systems are interoperated via a standard interface and a key relay is dynamically routed by SDN.

Authors:Joo Cho, ADVA Optical Networking SE / José Juan Pedreño Manresa, ADVA Optical Networking SE / Sai Patri, ADVA Optical Networking SE / Andrew Sergeev, ADVA Optical Networking SE / Jörg-Peter Elbers, ADVA Optical Networking SE / Helmut Griesser, ADVA Optical Networking SE / Catherine White, BT Labs / Andrew Lord, BT Labs

M2B.5

Demonstration of Machine-Intelligent Soft-Failure Localization Using SDN Telemetry

Presenter: Rossano Pinto , *UNICAMP*

We demonstrate a soft-failure localization framework using SDN-based network-wide telemetry. Soft failures are generated in a small-scale laboratory environment and collected in an SDN architecture. Failure localization is accomplished by ML algorithms.

Authors:Rossano Pinto, UNICAMP / Kayol Mayer, UNICAMP / Jonathan Soares, UNICAMP / Dalton Arantes, UNICAMP / Darli Mello, UNICAMP / Vinícius Cavalcante, Padtec / Leonardo Santos, Padtec / Filipe Moraes, Padtec / Christian Rothenberg, UNICAMP

M2B.6

Demonstration of ML-Aided Impairment-Aware L0 Path Computation in Fully Disaggregated Multi-Vendor Optical Transport Networks

Presenter: Huy Tran , *NOKIA Bell Labs*

We demonstrate an online impairment-aware L0 path computation capability leveraging a machine learning model to recommend the most appropriate optical parameters and path combination for a connectivity service request in the fully disaggregated multi-vendor optical transport network.

Authors:Huy Tran, NOKIA Bell Labs / Quan Pham-Van, NOKIA Bell Labs / Dominique Verchère, NOKIA Bell Labs / Huu-Trung Thieu, NOKIA Bell Labs / Djamal Zeghlache, Telecom SudParis

M2B.7

Inter-Operator Machine Learning Model Trading Over Acumos AI Federated Marketplace

Presenter: Behnam Shariati , *Fraunhofer Inst Nachricht Henrich-Hertz*

We demonstrate the development of a QoT classifier over an autonomous machine-learning pipeline, the trading of the classifier over a federated marketplace, and eventually its deployment in the customer's network as a cloud-native micro-service.

Authors:Behnam Shariati, Fraunhofer Inst Nachricht Henrich-Hertz / Pooyan Safari, Fraunhofer Inst Nachricht Henrich-Hertz / Geronimo Bergk, Fraunhofer Inst Nachricht Henrich-Hertz / Felix Immanuel Oertel, Fraunhofer Inst Nachricht Henrich-Hertz / Johannes Fischer, Fraunhofer Inst Nachricht Henrich-Hertz

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M2B.8

SDN-Controlled Dynamic Front-Haul Provisioning, Emulated on Hardware and Virtual COSMOS Optical x-Haul Testbeds

Presenter: Bob Lantz , *University of Arizona*

We demonstrate SDN-controlled dynamic front-haul optical network provisioning and modulation format adaptation, running on an emulation of the COSMOS testbed benchmarked against the COSMOS hardware testbed.

Authors:Bob Lantz, University of Arizona / Jiakai Yu, University of Arizona / Ayush Bhardwaj, Trinity College Dublin / Alan Díaz Montiel, Trinity College Dublin / Aamir Quraishy, University of Arizona / Steven Santaniello, University of Arizona / Tingjun Chen, Duke University / Rina Fujieda, University of Arizona / Atri Mukhopadhyay, Trinity College Dublin / Gil Zussman, Columbia University / Marco Ruffini, Trinity College Dublin / Daniel Kilper, University of Arizona

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M2B.9

Experimental Demonstration of Scalable and Low Latency Crowd Management Enabled by 5G and AI in an Accelerated Edge Cloud

Presenter: Luca Valcarenghi , *Scuola Superiore Sant Anna di Pisa*

This demo shows how crowd management can benefit from 5G connectivity and accelerated edge cloud AI-based computation to achieve low latency and scalability with respect to a mobile device-based physical distancing computation.

Authors:Justine Borromeo, Scuola Superiore Sant Anna di Pisa / Koteswararao Kondepu, IITDharwad / Silvia Fichera, Scuola Superiore Sant Anna di Pisa / Piero Castoldi, Scuola Superiore Sant Anna di Pisa / Luca Valcarenghi, Scuola Superiore Sant Anna di Pisa

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M2B.10

Demonstration of P4 Neural Network Switch

Presenter: Filippo Cugini , *CNIT*

A programmable P4 node performing neural network acceleration is demonstrated. The node implements both traffic feature extraction and neural networking computations. Cyber security use case targeting DDoS attack detection is deployed.

Authors:Francesco Paolucci, CNIT / Lorenzo De Marinis, Scuola Superiore Sant'Anna / Piero Castoldi, Scuola Superiore Sant'Anna / Filippo Cugini, CNIT

8:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

SC325

Short Course - SC325 - Highly Integrated Monolithic Photonic Integrated Circuits

SC327

Short Course - SC327 - Modeling and Design of Long-Haul Fiber-Optic Communication Systems

SC328

Short Course - SC328 - Standards for High-Speed Optical Networking

SC347

Short Course - SC347 - Reliability and Qualification of Fiber-Optic Components

SC357

Short Course - SC357 - Circuits and Equalization Methods for Coherent and Direct Detection Optical Links

SC443

Short Course - SC443 - Optical Amplifiers: From Fundamental Principles to Technology Trends

SC472

Short Course - SC472 - Hands-on: Controlling and Monitoring Optical Network Equipment

SC473

Short Course - SC473 - Photonic Switching Systems

9:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

SC261

Short Course - SC261 - ROADM Technologies and Network Applications

9:30 - 10:00 Pacific Time (US & Canada) (UTC - 07:00)

Special Event - Demo Zones Demonstrations in Action

10:00 - 11:30 Pacific Time (US & Canada) (UTC - 07:00)

M3I

Coherent Transceivers and Transmission

Presider: Hung-Chang Chien

M3I.1

4096-ary Eigenvalue Modulation Using 12 Triangular-Lattice-Shaped Eigenvalues

Presenter: Ken Mishina , *Osaka University*

We experimentally demonstrate the transmission of a 4096-ary eigenvalue-modulated signal using 12 triangular-lattice-shaped eigenvalues. A 50-km transmission with a BER < 3.8×10^{-3} at 11.25 Gb/s is achieved successfully.

Authors:Ken Mishina, Osaka University / Hiroyuki Takeuchi, Osaka University / Takeyuki Kodama, Osaka University / Yuki Yoshida, National Institute of Information and Communications Technology (NICT) / Daisuke Hisano, Osaka University / Akihiro Maruta, Osaka University

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M3I.2

882 Gbps Transmission Over 100 km of SSMF Using a Self-Calibrated Single-Ended Coherent Receiver

Presenter: Son Le , *Nokia Bell Labs*

We propose a self-calibration technique for single-ended coherent receivers and demonstrate a record net data rate of 882 Gbps over 100 km of SSMF using either a direct field reconstruction scheme or a clipped iterative SSBI cancellation scheme

Authors:Son Le, Nokia Bell Labs / Vahid Aref, Nokia Bell Labs / Junho Cho, Nokia Bell Labs / Xi Chen, Nokia Bell Labs / Di Che, Nokia Bell Labs

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M3I.3

Techniques for Subsea Transmission Systems

Invited

Presenter: Massimiliano Salsi , *Google*

We review the most significant innovations happening in the submarine cable systems domain. The review includes wet-plant and transponder technologies, ranging from optical fiber switching in the branching units to advanced signal processing for earthquake detection.

Authors:Massimiliano Salsi, Google

M3I.4

Digital Compensation of Residual Pump Dithering in Optical Phase Conjugation of High-Order QAM

Presenter: Sonia Boscolo , *Aston University*

We develop a new two-stage digital scheme to suppress the phase distortion due to residual pump dithering in the dual-pump fibre-based optical phase conjugation of high-order (64/256) QAM signals. We show more than 5-dB SNR improvement relative to conventional phase-noise compensation at high pump-phase mismatch levels.

Authors:Tu Nguyen, Aston University / Sonia Boscolo, Aston University / Abdallah Ali, Aston University / Mingming Tan, Aston University / Stylianos Sygletos, Aston University / Shigehiro Takasaka, Furukawa Electric / Ryuichi Sugizaki, Furukawa Electric / Andrew Ellis, Aston University

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M3I.5

Revealing Raman-Amplified Power Profile and Raman Gain Spectra With Digital Backpropagation

Presenter: Takeo Sasai , *NTT Corporation*

We demonstrate the acquisition of signal power evolution and Raman gain spectra (RGS) in multi-span Raman-amplified links with digital backpropagation. We successfully identify the individual RGS of each Raman-amplified span separately.

Authors:Takeo Sasai, NTT Corporation / Masanori Nakamura, NTT Corporation / Takayuki Kobayashi, NTT Corporation / Hiroto Kawakami, NTT Corporation / Etsushi Yamazaki, NTT Corporation / Yoshiaki Kisaka, NTT Corporation

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10:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

M3A

Silicon Photonics in Communications and Beyond

Presider: Zuowei Shen

M3A.1

Edge-Coupled Active and Passive Wafer-Scale Measurements on 300mm Silicon Photonics Wafers

Presenter: Kenneth Jabon , *Analog Photonics*

We perform wafer-scale measurements of silicon photonics components using broadband (100nm+) edge couplers and reflecting optical fiber probes for the first time. We demonstrate <1dB/cm waveguide loss and 25GHz+ micro-ring modulators on 300mm wafers.

Authors:Kenneth Jabon, Analog Photonics / Christopher Poulton, Analog Photonics / Ren-Jye Shiue, Analog Photonics / Matthew Byrd, Analog Photonics / Zhan Su, Analog Photonics / Mohammad Teimourpour, Analog Photonics / Scott Breitenstein, Analog Photonics / Ronald Millman Jr., Analog Photonics / Dogan Atlas, Analog Photonics / Michael Watts, Analog Photonics / Erman Timurdogan, Analog Photonics

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M3A.2

Integrated Silicon Photonics Transmitter in 400GBASE-DR4 QSFP-DD Transceiver

Presenter: Xingyu Zhang , *Alpine Optoelectronics, Inc.*

We present the design and characterization of a 4-channel silicon photonics transmitter for 400Gbps DR4 data-center applications. A QSFP-DD transceiver module with this transmitter is demonstrated with reliable performance in real-time operation across 0~70 °C.

Authors:Xingyu Zhang, Alpine Optoelectronics, Inc. / David Zheng, Alpine Optoelectronics, Inc. / Zhoufeng Ying, Alpine Optoelectronics, Inc. / Yong Li, Alpine Optoelectronics, Inc. / Ming Ding, Alpine Optoelectronics, Inc. / Dobby Lam, Alpine Optoelectronics, Inc. / Shijun Tu, Eoptolink Technology Inc., Ltd / Rui Wu, Eoptolink Technology Inc., Ltd / Xia Zhang, Eoptolink Technology Inc., Ltd / Yonghuan Sun, Eoptolink Technology Inc., Ltd / Xiong Wang, Eoptolink Technology Inc., Ltd / Xiaolei Huang, Eoptolink Technology Inc., Ltd / Tongqing Wang, Alpine Optoelectronics, Inc.

M3A.3

Integrated Silicon Photonics Transceiver Module for 100Gbit/s 20km Transmission

Presenter: Matthew Traverso , *Cisco Systems Inc*

The architecture, packaging, and performance of a Silicon Photonics single transceiver chip PAM4 optical QSFP28 transceiver module for 100 Gigabit Ethernet compliant to 100GBASE-LR1 for 10km and extendable to over 20km SMF transmission is described.

Authors:Matthew Traverso, Cisco Systems Inc / Marco Mazzini, Cisco Systems Inc / Kumar Lakshmikumar, Cisco Systems Inc / Sanjay Sunder, Cisco Systems Inc / Alex Kurylak, Cisco Systems Inc / Craig Appel, Cisco Systems Inc / Cristiana Muzio, Cisco Systems Inc / Ravi Tummidi, Cisco Systems Inc / Romesh Kumar Nandwana, Cisco Systems Inc / Alberto Cervasio, Cisco Systems Inc / Mary Nadeau, Cisco Systems Inc / Weizhuo Li, Cisco Systems Inc / Jarrett Neiman, Cisco Systems Inc / Jock Bovington, Cisco Systems Inc / Mark Webster, Cisco Systems Inc

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M3A.4

System Optimization of High-Efficiency 400 Gb/s PAM4 Silicon Photonics Transmitter for Data Center Applications

Presenter: Siamak Amiralizadeh , *Intel Corp.*

We demonstrate a high-efficiency PAM4 silicon photonics transmitter optimized through end-to-end system modeling for applications up to 10km on four-channel CWDM4 grid. Our measurements show a close agreement with simulations meeting 400G-FR4 requirements with 1.7Vppd

Authors:Siamak Amiralizadeh, Intel Corp. / Wenhua Lin, Intel Corp. / David Patel, Intel Corp. / Yann Malinge, Intel Corp. / Stefan Burmeister, Intel Corp. / Kadhair Al-hemyari, Intel Corp. / Haijiang Yu, Intel Corp. / Jung Park, Intel Corp. / Christian Malouin, Intel Corp. / Kejia Li, Intel Corp. / Pengyue Wen, Intel Corp. / Xueyan Zheng, Intel Corp. / Sanjeev Gupta, Intel Corp. / Raghuram Narayan, Intel Corp. / Ansheng Liu, Intel Corp. / Daniel Zhu, Intel Corp. / Boping Xie, Intel Corp. / Yuliya Akulova, Intel Corp. / Sunil Priyadarshi, Intel Corp. / Charlie Wang, Intel Corp. / Jin Hong, Intel Corp.

M3A.5

Silicon Photonics Applications for 5G and Data Centers

Invited

Presenter: Rang-Chen Yu , *SiFotonics Technologies Co., Ltd.*

We review silicon photonics devices, such as Ge/Si APD detectors, and integrated circuits for 5G wireless and data center applications.

Authors:Rang-Chen Yu, SiFotonics Technologies Co., Ltd. / Dong Pan, SiFotonics Technologies Co., Ltd.

M3B

Quantum Communication and Photonic Computing

Presider: Martin Schell

M3B.1

Time-Energy Entangled Photon Pairs Generated via SFWM in an AlGaAsOI Ring Resonator

Presenter: Joshua Castro , *UCSB*

We report a time-energy entangled photon pair source from an AlGaAs microring resonator with an internal generation rate greater than 20×10^9pairs sec^(−1) mW^(−2) while maintaining high heralded single photon purity > 99% and visibility > 97%.

Authors:Joshua Castro, UCSB / Trevor Steiner, UCSB / Lin Chang, UCSB / Quynh Dang, UCSB / Weiqiang Xie, UCSB / chenlei li, UCSB / justin norman, UCSB / John Bowers, UCSB / galan moody, UCSB

M3B.2

Photonic Assisted Computing

Invited

Presenter: Wolfram Pernice , *Universität Münster*

Abstract not available.

Authors:Wolfram Pernice, Universität Münster

M3B.3

Cryo-Compatible, Silicon Spoked-Ring Modulator in a 45nm CMOS Platform for 4K-to-Room-Temperature Optical Links

Presenter: Hayk Gevorgyan , *Boston University*

Cryogenic operation, at 4.5K, of a vertical-junction silicon microring modulator in a 45 nm CMOS platform is demonstrated. Record resonance-shift efficiency – 46 GHz/V – enables nonthermal tuning in 140 GHz range and up to 10 Gbps OOK modulation with ≤1 V_{pp} drive, paving the way to cryogenic optical data egress links.

Authors:Hayk Gevorgyan, Boston University / Anatol Khilo, Boston University / Derek Van Orden, Ayar Labs Inc. / Deniz Onural, Boston University / Bozhi Yin, University of California, Berkeley / Mark Wade, Ayar Labs Inc. / Vladimir Stojanovic, University of California, Berkeley / Milos Popovic, Boston University

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M3B.4

Compact and Inexpensive Photonic Ising Machines Based on Optoelectronic Oscillators

Invited

Presenter: Guy Van der Sande , *Vrije Universiteit Brussel*

Photonic Ising machines based on optoelectronic oscillators are a compact and inexpensive alternative to coherent Ising machines and quantum annealers. Based on experiments and simulations, we demonstrate similar or improved compared to state-of-the-art Ising machines.

Authors:Guy Van der Sande, Vrije Universiteit Brussel / Fabian Böhm, Vrije Universiteit Brussel / Thomas Van Vaerenbergh, Hewlett Packard Labs / Guy Verschaffelt, Vrije Universiteit Brussel

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M3B.5

Multi-Channel Quantum Communication Receiver Made From Waveguide-Integrated Superconducting Nanowire Single-Photon Detectors

Presenter: Matthias Häußler , *University of Münster*

We present a fiber-coupled multi-channel waveguide-integrated superconducting single-photon detector array for fast, efficient and highly parallelized counting with below 65 ps timing accuracy for high-rate quantum key distribution implementations at telecommunication wavelengths.

Authors:Matthias Häußler, University of Münster / Robin Terhaar, University of Münster / Helge Gehring, University of Münster / Martin Wolff, University of Münster / Fabian Beutel, University of Münster / Wladick Hartmann, University of Münster / Nicolai Walter, University of Münster / Max Tillmann, PicoQuant GmbH / Michael Wahl, PicoQuant GmbH / Tino Röhlicke, PicoQuant GmbH / Hans-Jürgen Rahn, PicoQuant GmbH / Doreen Wernicke, Entropy GmbH / Nicolas Perlot, Fraunhofer Heinrich Hertz Institute / Jasper Rödiger, Fraunhofer Heinrich Hertz Institute / Wolfram Pernice, University of Münster / Carsten Schuck, University of Münster

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M3C

Optimization of Single-mode Fibers and Cables

Presider: Lara Garrett

M3C.1

Optimizations of Thin Glass Diameter Fibers

Presenter: Kazunori Mukasa , *Furukawa Electric Co., Ltd.*

Thin diameter fibers with 80um cladding diameters were designed and fabricated. The limitation of total fiber diameters was investigated for step- and 2-types trench-index fibers taking ITU-T standard, micro-bending loss, and mechanical reliabilities, into account.

Authors:Kazunori Mukasa, Furukawa Electric Co., Ltd. / Tamás Mihálffy, Furukawa Electric Institute of Technology / Zoltán Várallyay, Furukawa Electric Institute of Technology

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M3C.2

Thin-Coated Fibers for High-Density Optical Interconnects

Presenter: Ming-Jun Li , *Corning Inc*

Thin coated single-mode fibers with coating diameters from 125 to 175 μm are fabricated and characterized. The fibers show excellent coating concentricity and attenuation similar to 250 μm coated fiber on shipping reels.

Authors:Weijun Niu, Corning Inc / Matthew Drake, Corning Inc / Brett Knowlton, Corning Inc / Yali Zhang, Corning Inc / Arthur Wallace, Corning Inc / Jeffery Stone, Corning Inc / Yunfeng Gu, Corning Inc / Shandon Hart, Corning Inc / Hector de Pedro, Corning Inc / Aramais Zakharian, Corning Inc / Ming-Jun Li, Corning Inc

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M3C.3

1,728-Fiber Cable With 12-Fiber Ribbons Comprising 160-μm Coating Fiber With 80-μm Cladding

Presenter: Shoichiro Matsuo , *Fujikura Ltd.*

The availability of a 160-μm fiber with 80-μm cladding is demonstrated through the performance of a 1,728-fiber cable with 12-fiber ribbons, fusion-splicing loss of ribbonized fiber, and loss of MPO connection to a 125-μm-cladding fiber.

Authors:Shoichiro Matsuo, Fujikura Ltd. / Kenji Yamashiro, Fujikura Ltd. / Kazuaki Hoshi, Fujikura Ltd. / Yusuke Tsujimoto, Fujikura Ltd. / Miku Miyata, Fujikura Ltd. / Hirotaka Asada, Fujikura Ltd. / Toshiaki Nakajima, Fujikura Ltd. / Ken Osato, Fujikura Ltd.

M3C.4

Autonomous Physical Layer Characterization in Cognitive Optical Line Systems

Presenter: Giacomo Borraccini , *Politecnico di Torino*

We develop a procedure to autonomously characterize the optical line system physical layer, span-by-span, using in-line OTDRs and OCMs. This procedure has been experimentally validated, showing a clear correlation between the experimental outcomes and emulations.

Authors:Giacomo Borraccini, Politecnico di Torino / Stefano Straullu, LINKS Foundation / Andrea D'Amico, Politecnico di Torino / Antonino Nespola, LINKS Foundation / Stefano Piciaccia, Cisco Photonics / Alberto Tanzi, Cisco Photonics / Gabriele Galimberti, Cisco Photonics / Vittorio Curri, Politecnico di Torino

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M3C.5

Estimating Nonlinear Phase Shift in a Multi-Span Fiber-Optic Link Using a Coherent Transceiver

Presenter: Rongqing Hui , *University of Kansas*

We demonstrate a novel technique to measure the nonlinear phase shifts of multi-span fiber optic links with a polarization-multiplexed coherent transceiver based on cross-phase modulation between two orthogonally polarized subcarrier tones.

Authors:Rongqing Hui, University of Kansas / Maurice O'Sullivan, Ciena Corp.

M3C.6

Estimation of Core-Cladding Concentricity Error From GAWBS Noise Spectrum

Presenter: Fatih Yaman , *NEC Laboratories America Inc*

CCCE in a 60-km fiber is estimated from its GAWBS noise spectrum by comparing the TR_{1m} modes with the R_{0m} modes. The estimated CCCE value 0.73 μm is consistent with conventional measurements of 0.6–0.8 μm.

Authors:Fatih Yaman, NEC Laboratories America Inc / Kohei Nakamura, NEC Corporation / Eduardo Mateo, NEC Corporation / Shinsuke Fujisawa, NEC Laboratories America Inc / Hussam Batshon, NEC Laboratories America Inc / Takanori Inoue, NEC Corporation / Yoshihisa Inada, NEC Corporation

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M3C.7

A BiLSTM-CNN Based Multitask Learning Approach for Fiber Fault Diagnosis

Presenter: Khouloud Abdelli , *Adva optical network*

A novel multitask learning approach based on stacked bidirectional long short-term memory (BiLSTM) networks and convolutional neural networks (CNN) for detecting, locating, characterizing, and identifying fiber faults is proposed. It outperforms conventionally employed techniques.

Authors:Khouloud Abdelli, Adva optical network / Helmut Griesser, Adva optical network / Stephan Pachnicke, Kiel University / Carsten Tropschug, Adva optical network

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M3C.8

Lightning-Induced State of Polarization Change in OPGW Using a Transmission Line Model

Presenter: William Snider , *University of Florida*

A transmission line model is employed to study the effects of direct lightning strikes on the state of polarization of optical signals within an optical ground wire.

Authors:William Snider, University of Florida / Robert Moore, University of Florida / Anthony Erdman, University of Florida / Dave Doucet, Ciena / Doug Charlton, Ciena

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M3D

Spatial Division Multiplexing Devices and Amplifiers

Presider: Yong-min Jung

M3D.1

Cladding-Pumped Multicore Amplifiers With Ring Doping

Invited

Presenter: Sophie LaRochelle , *Universite Laval*

Spatially integrated amplifiers with cladding-pumping reduce subsystem port count. In these amplifiers, ring doping can help to overcome gain compression, a critical parameter in dynamic networks. We review recent progress in an 8-core amplifier design.

Authors:Sophie LaRochelle, Universite Laval / Charles Matte-Breton, Universite Laval / Colin Kelly, Nokia Canada / Rene-Jean Essiambre, Nokia Bell Labs

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M3D.2

High Spatial Channel Count Multicore SDM Amplifiers

Invited

Presenter: Saurabh Jain , *University of Southampton*

We present recent advances in high spatial density multicore fiber amplifiers. The potential operational benefits are presented in comparison to standard erbium-doped fiber amplifiers and the potential cost/power saving benefits discussed.

Authors:Saurabh Jain, University of Southampton

M3D.3

FIFO-Less Core-Pump Combiner for Multicore Fiber Amplifier

Presenter: Yuta Wakayama , *KDDI Research*

We demonstrate a core-pumping scheme for multicore EDFA with cascaded side-polished fiber couplers for the first time. The pump coupling ratio exceeds 70% while keeping signal coupling less than 10%.

Authors:Yuta Wakayama, KDDI Research / Noboru Yoshikane, KDDI Research / Takehiro Tsuritani, KDDI Research

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M3D.4

Hermite-Gaussian Mode Multiplexer Supporting 1035 Modes

Presenter: Nicolas Fontaine , *Nokia Bell Labs*

We present a multi-plane light conversion based mode multiplexer supporting 1035 Hermite-Gaussian modes. It is characterized using spot scanning at the input and digital holography at the output.

Authors:Nicolas Fontaine, Nokia Bell Labs / Haoshuo Chen, Nokia Bell Labs / Mikael Mazur, Nokia Bell Labs / Lauren Dallachiesa, Nokia Bell Labs / kw kim, Nokia Bell Labs / Roland Ryf, Nokia Bell Labs / David Neilson, Nokia Bell Labs / joel carpenter, University of Queensland

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M3D.5

Parallel Phase Stabilization of 45 Single-Mode Fiber Inputs Feeding a Mode Multiplexer

Presenter: Mikael Mazur , *Nokia Bell Labs*

We demonstrate simultaneous phase stabilization of 45 parallel input spatial channels to a mode multiplexer. The phase errors for all output modes are calculated using digital holography and fed back to parallel piezo-based fiber stretchers.

Authors:Mikael Mazur, Nokia Bell Labs / Nicolas Fontaine, Nokia Bell Labs / Lauren Dallachiesa, Nokia Bell Labs / Haoshuo Chen, Nokia Bell Labs / Roland Ryf, Nokia Bell Labs / Louis-Anne De Montmorillon, Prysmian Group / Pierre Sillard, Prysmian Group / David Neilson, Nokia Bell Labs

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M3D.6

4.36 Tbit/s Silicon Chip-to-Chip Transmission via Few-Mode Fiber (FMF) Using 2D Sub-Wavelength Grating Couplers

Presenter: PinCheng Guo , *National Chiao Tung University*

We demonstrate a high-speed silicon chip-to-chip few-mode-fiber (FMF) transmission via 2D sub-wavelength grating-couplers. The design and characterization of the proposed silicon device are discussed. A total FMF transmission capacity of 4.36 Tbit/s is achieved.

Authors:PinCheng Guo, National Chiao Tung University / Yeyu Tong, Chinese University of Hong Kong / Chi-Wai Chow, National Chiao Tung University / Jui-Feng Tsai, National Chiao Tung University / Yang Liu, Philips Electronics Ltd / You-Chia Chang, National Chiao Tung University / Chien-Hung Yeh, Feng Chia University / Hon Tsang, Chinese University of Hong Kong

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M3E
Advanced Network Architectures: Techno-economics and Performance

Presider: Mark Filer

M3E.1

Scaling Regional Optical Transport Networks With Pluggable and Integrated High-Capacity Line Interfaces

Presenter: João Pedro , *Infinera Corporation*

This paper provides insight on the role of next-generation coherent interfaces and use of an extended C-band to cost-effectively scale regional transport networks.

Authors:João Pedro, Infinera Corporation / Nelson Costa, Infinera Corporation / Steve Sanders, Infinera Corporation

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M3E.2

Comparing IP-Optical Architectures & WDM Transport Technologies in Metro, Regional and Long-Haul Networks

Presenter: serge melle , *Nokia*

Different IP-Optical architectures, technologies and performance metrics are presented for metro, regional and long-haul networks, comparing single-hop and optimized bypass router topologies, using 400G pluggable transceivers and higher-baud rate transponder coherent optics.

Authors:serge melle, Nokia / Thierry Zami, Nokia / oriol bertran-pardo, Nokia / Bruno Lavigne, Nokia

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M3E.3

Towards Dynamic Network Reconfigurations for Flexible Optical Network Planning

Presenter: Amir Varasteh , *Technical University of Munich*

We propose a network reconfiguration heuristic, incorporating provisioning, upgrading, and rerouting of lightpaths for multi-period planning. Using the same physical network infrastructure, we achieve up to 33% increase in network throughput compared to the state-of-the-art.

Authors:Amir Varasteh, Technical University of Munich / Sai Patri, Technical University of Munich / Achim Autenrieth, Adva Optical Networking / Carmen Mas-Machuca, Technical University of Munich

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M3E.4

Performance Comparison of Translucent C-Band and Transparent C+L-Band Network

Presenter: Raoul Sadeghi Yamchi , *Politecnico di Torino*

We compare transparent and translucent network design in terms of capacity, energy consumption, and cost. Results show that exploiting extra spectrum bands is more beneficial than deploying additional regenerators in the C-band.

Authors:Raoul Sadeghi Yamchi, Politecnico di Torino / Bruno Correia, Politecnico di Torino / Emanuele Virgillito, Politecnico di Torino / Antonio Napoli, Infinera / Nelson Costa, Infinera / João Pedro, Infinera / Vittorio Curri, Politecnico di Torino

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M3E.5

Missing Pieces Currently Preventing Effective Application of Machine Learning to QoT Estimation in the Field

Invited

Presenter: Jelena Pesic , *Nokia*

Despite significant effort from the research community, there are still some missing pieces currently preventing the application of machine learning to QoT estimation in WDM networks. This paper highlights these pieces.

Authors:Jelena Pesic, Nokia

M3E.6

QoT-E Driven Optimized Amplifier Control in Disaggregated Optical Networks

Presenter: Giacomo Borraccini , *Politecnico di Torino*

We propose a vendor-agnostic framework exploiting QoT estimation to control EDFA settings targeting maximum GSNR average and flatness. We demonstrated its effectiveness by an experimental proof of concept exploiting open HW and SW by TIP.

Authors:Giacomo Borraccini, Politecnico di Torino / Stefano Straullu, LINKS Foundation / Andrea D'Amico, Politecnico di Torino / Emanuele Virgillito, Politecnico di Torino / Lalit Kumar, IP Infusion / Stefano Piciaccia, Cisco Photonics / Stefano Bottacchi, Lumentum / Scott Swail, Lumentum / Gabriele Galimberti, Cisco Photonics / Vittorio Curri, Politecnico di Torino

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M3E.7

Adaptive and Iterative QoT Estimator Retraining for Launch Power Optimization

Presenter: Ankush Mahajan , *CTTC*

We dynamically optimize the transponders launch powers with iterative closed control loops. We close the loop after an adaptable number of algorithm’s intermediate calculations, to monitor and retrain the QoT estimator with the real world.

Authors:Ankush Mahajan, CTTC / Konstantinos (Kostas) Christodoulopoulos, Nokia Bell Lbas / Ricardo Martínez, CTTC / Raul Muñoz, CTTC / Salvatore Spadaro, UPC

M3F

DC/Access Networks

Presider: Frank Effenberger

M3F.1

Network Use Cases of ZR Optics, State of Development and Standardisation

Invited

Presenter: Walid Wakim , *Cisco Systems Inc*

Technological inflection points within Optical Networking has challenged us to rethink Network Architectures, from ROADM to Coherent Optics and now ZR optics. The impact of ZR optics on network architectures will be discussed in this talk.

Authors:Walid Wakim, Cisco Systems Inc

M3F.2

Silicon Photonic ZR/ZR+ DCO-CFP2 Interface for DCI and Metro-Regional 400G Optical Communications

Presenter: Erwan Pincemin , *Orange Labs*

For the first time, a 400-Gbps DP-16QAM silicon photonic DCO-CFP2 interface using standardized C-FEC (400-ZR) and O-FEC (400-ZR+) and consuming less than 20-Watts is presented and evaluated, confirming its interest for DCI and metro-regional optical networks.

Authors:Erwan Pincemin, Orange Labs / Yann Loussouarn, Orange Labs

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M3F.3

Field Trial of a System-Independent Infrastructure Monitoring System for Access Networks

Presenter: Michael Straub , *Nokia Bell Labs Germany*

We introduce transmission system independent infrastructure monitoring capabilities for optical access networks to monitor status, availability and connectivity of ODN splitters and endpoints. A Field Trial at municipal utilities Sindelfingen/Germany demonstrates full operation on deployed field-fibers.

Authors:Michael Straub, Nokia Bell Labs Germany / Volker Hückstädt, Stadtwerke Sindelfingen / Marc Ulrich, Nokia Bell Labs Germany / Thomas Pfeiffer, Nokia Bell Labs Germany / Rene Bonk, Nokia Bell Labs Germany

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M3F.4

Low Cost Optical Access Technologies for Wireless X-Haul - What are the Optimal Deployment Scenarios

Invited

Presenter: Pascal Dom , *Nokia Corporation*

Abstract not available.

Authors:Pascal Dom, Nokia Corporation

M3F.5

25 and 50G Optical Access Network Deployment Forecasts Using Bi-Logistic Curves

Presenter: Cláudio Rodrigues , *Altice Labs*

Different forecast scenarios for both 25G-PON and 50G-PON global ONT/ONU market are presented based on a Bi-Logistic modeling function with reference to GPON existing data.

Authors:Cláudio Rodrigues, Altice Labs / Francisco Rodrigues, PicAdvanced / Cátia Pinho, University of Aveiro / Nuno Bento, ISCTE / Marlene Amorim, University of Aveiro / António Teixeira, University of Aveiro

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M3G

DSP and AI for PON Transmission

Presider: Luca Valcarenghi

M3G.1

Linear Burst-Mode Receivers for DSP-Enabled Passive Optical Networks

Invited

Presenter: Xin Yin , *Ghent University-imec*

High-dynamic-range and fast-response burst-mode receivers have become a prerequisite for time-division multiplexed passive optical networks (TDM-PON). Recent progress in high-rate burst-mode receiving technologies optimized for linear operation enables upstream equalization or DSP for future PONs.

Authors:Xin Yin, Ghent University-imec / Gertjan Coudyzer, Ghent University-imec / Peter Ossieur, Ghent University-imec / Laurens Breyne, Ghent University-imec / Borre Van Lombergen, Ghent University-imec / Johan Bauwelinck, Ghent University-imec

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M3G.2

Recurrent Neural Network Based Equalizer With Embedded Parallelization for 100Gbps/λ PON

Presenter: XIAOAN HUANG , *Nokia Bell Labs*

Recurrent neural network based equalizer with parallel outputs is proposed and experimentally demonstrated. Result shows that it outperforms fully-connected neural network for 100Gbps/λ PON using 25G-class optics. Hardware implementation issues are also discussed.

Authors:XIAOAN HUANG, Nokia Bell Labs / Dongxu Zhang, Nokia Bell Labs / Xiaofeng Hu, Nokia Bell Labs / Chenhui Ye, Nokia Bell Labs / Kaibin Zhang, Nokia Bell Labs

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M3G.3

Digital Predistortion Enhancement by Convolutional Neural Network for Probabilistic Shaped Discrete Multi-Tone Signal Transmission in Passive Optical Network

Presenter: Qi Zhou , *Georgia Institute of Technology*

We experimentally demonstrate a 68.2-Gb/s net data-rate probabilistic shaped discrete multi-tone transmission in passive optical network with 11G-class devices. The convolutional-neural-network strengthens digital predistortion performance with 1.1-dB improvement of system sensitivity over linear pre-equalization.

Authors:Qi Zhou, Georgia Institute of Technology / Rui Zhang, Georgia Institute of Technology / Shuyi Shen, Georgia Institute of Technology / CHIN-WEI HSU, Georgia Institute of Technology / Shuang Yao, Georgia Institute of Technology / Shang-Jen Su, Georgia Institute of Technology / Gee-Kung Chang, Georgia Institute of Technology

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M3G.4

>55-Gbps and 30-dB Loss Budget LR-OFDM PON Downstream Enabled by ANN-Based Predistortion

Presenter: Hong-Minh Nguyen *, National Chiao Tung University*

We proposed the ANN-based predistortion to mitigate nonlinear distortion in a 25- to 70-km IM/DD OFDM PON. Using 18-dBm launch power, the >55-Gbps downstream with 30-dB loss budget was demonstrated without nonlinear compensation at ONUs.

Authors:Hong-Minh Nguyen, National Chiao Tung University / Szu-Chi Huang, National Sun Yat-sen University / Chia Chien Wei, National Sun Yat-sen University / Chun-Yen Chuang, National Chiao Tung University / Jyehong Chen, National Chiao Tung University

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M3G.5

Impact of DFE on Soft-Input LDPC Decoding for 50G PON

Presenter: Amitkumar Mahadevan *, Nokia Bell Labs*

DFE induced error correlation and mutual information (MI) degradation penalize the 50G PON LDPC code soft-input decoding performance. Bit-interleaving across multiple codewords mitigates the correlated error penalty, but not the MI degradation penalty.

Authors:Amitkumar Mahadevan, Nokia Bell Labs / Yannick Lefevre, Nokia Bell Labs Antwerp / Wouter Lanneer, Nokia Bell Labs Antwerp / Paul Cautereels, Nokia Bell Labs Antwerp / Dora van Veen, Nokia Bell Labs / Noriaki Kaneda, Nokia Bell Labs / Vincent Houtsma, Nokia Bell Labs

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M3G.6

Performance Improvements in Bandwidth-Limited and Digitally-Equalized 50G-PON Downstream Transmission via Block-Interleaving Over Four LDPC Codewords

Presenter: Xiang Liu *, FutureWei Technologies Inc*

We experimentally quantify the performance improvements in bandwidth-limited 50G-PON downstream transmission with receiver-side equalization based on FFE, DFE and MLSE, by bit-interleaving of every four adjacent LDPC codewords, achieving 32-dB power budget with additional margins.

Authors:Xiang Liu, FutureWei Technologies Inc / Andy Shen, FutureWei Technologies Inc / Ning Cheng, FutureWei Technologies Inc / Yuanqiu Luo, FutureWei Technologies Inc / Frank Effenberger, FutureWei Technologies Inc

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M3H

AI Techniques and Advanced Processing

Presider: Marco Secondini

M3H.1

Digital Twin-Enabled Power Optimizer for Multi-Span Transmission System Using Autoencoder

Presenter: Shengnan Li , *Beijing University of Posts and Telecommunications*

A digital twin-enabled technique is proposed for multi-span system to build a neural network-based power prediction model and an autoencoder-based power optimization model achieve flexible output spectrum profile control.

Authors:Shengnan Li, Beijing University of Posts and Telecommunications / Danshi Wang, Beijing University of Posts and Telecommunications / Yuchen Song, Beijing University of Posts and Telecommunications / Qirui Fan, The Hong Kong Polytechnic University / Min Zhang, Beijing University of Posts and Telecommunications / Chao Lu, The Hong Kong Polytechnic University / Alan Lau, The Hong Kong Polytechnic University

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M3H.2

Experimental Study of Deep Neural Network Equalizers Performance in Optical Links

Presenter: Pedro Jorge Freire de Carvalho Souza , *Aston University*

We propose a convolutional-recurrent channel equalizer and experimentally demonstrate 1dB Q-factor improvement both in single-channel and 96xWDM, DP-16QAM transmission over 450km of TWC fiber. The new equalizer outperforms previous NN-based approaches and a 3-steps-per-span DBP.

Authors:Pedro Jorge Freire de Carvalho Souza, Aston University / Yevhenii Osadchuk, University of Athens / Bernhard Spinnler, Infinera / Wolfgang Schairer, Infinera / Antonio Napoli, Infinera / Nelson Costa, Infinera Unipessoal / Jaroslaw Prilepsky, Aston University / Sergei K Turitsyn, Aston University

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M3H.3

Geometric Shaping Optimization of 64-APSK Eigenvalue Transmission Based on Nonlinear Fourier Transform

Presenter: Junda Chen , *Huazhong University of Science and Technology*

We experimentally demonstrated a geometric shaped (GS) 64-APSK eigenvalue transmission. The diameter distributions of each circles are optimized, OSNR margin improvement in simultaneous and experiments reached 4.51 dB, and 2.98 dB respectively.

Authors:Junda Chen, Huazhong University of Science and Technology / Yizhao Chen, Huazhong University of Science and Technology / Ming Tang, Huazhong University of Science and Technology / deming liu, Huazhong University of Science and Technology

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M3H.4

Jointly Shaped Dual Polarization Systems

Presenter: Lutz Lampe , *University of British Columbia*

We present a probabilistic shaping algorithm whereby both polarization streams of a dual-polarized system are shaped together. The proposed method offers 0.2-0.92 dB gains over existing shaping schemes for the same block-length.

Authors:Mrinmoy Jana, University of British Columbia / Lutz Lampe, University of British Columbia / Jeebak Mitra, Huawei Canada / Chuandong Li, Huawei Canada

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M3H.5

Achievable Rate Comparison Between Probabilistically-Shaped Single-Carrier and Entropy-Loaded Multi-Carrier Signaling in a Bandwidth-Limited 1-Tb/s Coherent System

Presenter: Di Che , *Nokia Bell Labs*

We compare single- and multi-carrier (SC/MC) signaling in a 100-GBaud coherent system whose performance is mainly degraded by the bandwidth-limited transmitter, and reveal an MC advantage of 0.3 bits/symbol or 20-km reach extension over a single-span transmission.

Authors:Di Che, Nokia Bell Labs / Xi Chen, Nokia Bell Labs

M3H.6

On the Comparison of Single-Carrier vs. Digital Multi-Carrier Signaling for Long-Haul Transmission of Probabilistically Shaped Constellation Formats

Presenter: Kaoutar Benyahya , *Nokia Bell Labs*

We report on theoretical and experimental investigations of the nonlinear tolerance of single carrier and digital multicarrier approaches with probabilistically shaped constellations. Experimental transmission of PCS16QAM is assessed at 120 GBd over an ultra-long-haul distance.

Authors:Kaoutar Benyahya, Nokia Bell Labs / Amirhossein Ghazisaeidi, Nokia Bell Labs / Vahid Aref, Nokia Bell Labs / Mathieu Chagnon, Nokia Bell Labs / Aymeric Arnould, Nokia Bell Labs / Stenio Ranzini, Nokia Bell Labs / Haik Mardoyan, Nokia Bell Labs / Fred Buchali, Nokia Bell Labs / Jeremie Renaudier, Nokia Bell Labs

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M3H.7

Coupled-Channel Enhanced SSFM for Digital Backpropagation in WDM Systems

Presenter: stella civelli , *Scuola Superiore Sant'Anna*

A novel technique for digital backpropagation (DBP) in wavelength-division multiplexing systems is introduced and shown, by simulations, to outperform existing DBP techniques for approximately the same complexity.

Authors:stella civelli, Scuola Superiore Sant'Anna / Enrico Forestieri, Scuola Superiore Sant'Anna / Alexey Lotsmanov, Moscow Research Center, Huawei Technologies Co., Ltd. / Dmitry Razdoburdin, Moscow Research Center, Huawei Technologies Co., Ltd. / Marco Secondini, Scuola Superiore Sant'Anna

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M3H.8

Solving the Nonlinear SchröDinger Equation in Optical Fibers Using Physics-Informed Neural Network

Presenter: Xiaotian Jiang , *Beijing University of Posts and Telecommunications (BUPT)*

We constructed a physics-informed neural network (PINN) to solve the nonlinear Schrödinger equation for different input waveforms. Results show that PINN can accurately characterize pulse evolution in fibers with less complexity to SSFM methods.

Authors:Xiaotian Jiang, Beijing University of Posts and Telecommunications (BUPT) / Danshi Wang, Beijing University of Posts and Telecommunications (BUPT) / Qirui Fan, The Hong Kong Polytechnic University / Min Zhang, Beijing University of Posts and Telecommunications (BUPT) / Chao Lu, The Hong Kong Polytechnic University / Alan Lau, The Hong Kong Polytechnic University

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M3J

High-frequency Applications Using Microwave, Millimeter and Terahertz Photonics

Presider: Anthony Ng'oma

M3J.1

Millimeter-Wave and Terahertz Photonics for Communications and Sensors

Invited

Presenter: Tadao Nagatsuma , *Osaka University*

This paper presents an efficient use of telecom-based photonics technologies in millimeter-wave and terahertz systems, which include high-speed wireless communications in the 300-GHz and 600-GHz bands, and ultra-broadband millimeter-wave radars equipped on the drone.

Authors:Tadao Nagatsuma, Osaka University / Masayuki Fujita, Osaka University / LI Yi, Osaka University

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M3J.2

Demonstration of 470 GHz Bandwidth Wireless Transmitter Based on Photo-Mixer for Simultaneous Transmission of Photonics-Generated Signals in All-Band 6G Systems

Presenter: Li Zhao , *Fudan University*

We experimentally demonstrate a 40-510 GHz all-band wireless transmitter. This is the first demonstration that a single photo-mixer is used to support simultaneous multiple transmissions over millimeter and terahertz channels.

Authors:Li Zhao, Fudan University / Yitong Li, Beijing University of Posts and Telecommunications / Cuiwei Liu, Fudan University / Jianguo Yu, Beijing University of Posts and Telecommunications / Wen Zhou, Fudan University / Kaihui Wang, Fudan University / Yanyi Wang, Fudan University / Feng Zhao, Xian University of Posts and Telecommunications / Dongfang Ning, ZTE Corp. / Qingqing Fo, ZTE Corp. / Jianjun Yu, Fudan University

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M3J.3

28-GHz MmWave Hybrid Beamforming System Integrated With a 64-Element Glass Antenna

Presenter: Xinying Li , *Corning Research & Development Corporation*

A multi-Gb/s 28-GHz mmWave hybrid-beamforming system integrated with a 64-element antenna array fabricated on a Corning-glass-substrate is demonstrated. DSP-based adaptive-hybrid-algorithms are utilized to achieve both electronic beam-steering and multi-user operation with >23-dB inter-user interference suppression.

Authors:Xinying Li, Corning Research & Development Corporation / Po-Tsung (Boris) Shih, Corning Research & Development Corporation / Qing Ji, Corning Research & Development Corporation / Hou-Tzu (Kurt) Huang, Corning Research & Development Corporation / Solomon Abraha, Corning Research & Development Corporation / Cheolbok Kim, Corning Research & Development Corporation / David Peters, Corning Research & Development Corporation / David Castellana, Corning Research & Development Corporation / Anthony Ng'oma, Corning Research & Development Corporation

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M3J.4

Demonstration of 8-Channel 32-Gbit/s QPSK Wireless Communications at 0.28-0.33 THz Using 2 Frequency, 2 Polarization, and 2 Mode Multiplexing

Presenter: Xinzhou Su , *University of Southern California*

We experimentally demonstrate a 32-Gbit/s QPSK THz wireless communication link using 2 frequencies, 2 polarizations and 2 OAM modes at ~0.3 THz. By tuning the frequency of the data-carrying lasers and the interfering CW laser, the system can cover the 0.28-0.33 THz band.

Authors:Xinzhou Su, University of Southern California / Huibin Zhou, University of Southern California / Kaiheng Zou, University of Southern California / Amir Minoofar, University of Southern California / Hao Song, University of Southern California / Runzhou Zhang, University of Southern California / Kai Pang, University of Southern California / Haoqian Song, University of Southern California / Nanzhe Hu, University of Southern California / Zhe Zhao, University of Southern California / Ahmed Almaiman, University of Southern California / Shlomo Zach, Tel Aviv University / Moshe Tur, Tel Aviv University / Andreas Molisch, University of Southern California / Hirofumi Sasaki, NTT Network Innovation Laboratories / Doohwan Lee, NTT Network Innovation Laboratories / Alan Willner, University of Southern California

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M3J.5

Fronthaul Optical Links Implemented by Using Sub-Nyquist Sampling Rate ADC for B5G/6G Sub-THz

Presenter: SHAO-HUNG YU , *National Chiao Tung University*

We propose fronthaul link with 7-GHz IM-DD channels and 1/64 Nyquist-sampling-rate ADC to support 64 signals for 100-GHz Ma-MIMO beamforming. The corresponding CPRI-based capacity is 393.6374Gb/s. After fiber and wireless transmission, the EVMs are <8%.

Authors:Pin Hsuan Ting, National Chiao Tung University / SHAO-HUNG YU, National Chiao Tung University / Zheng-Wei Huang, National Chiao Tung University / Chia Chien Wei, National Sun Yat-sen University / Sien Chi, National Chiao Tung University / Chun-Ting Lin, National Chiao Tung University

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M3J.6

Compact K-Band Photonic Beamsteerer Assisted With Weakly-Coupled Multi-Core Fiber

Presenter: Eduward Tangdiongga , *Technische Universiteit Eindhoven*

An optical beamsteerer of a photonic integrated circuit employing a weakly-coupled multi-core fiber enables 3-GHz bandwidth in the 24 GHz RF band and a scanning range of 59°, resulting in 16QAM 12 Gbps.

Authors:Ailee Trinidad, Technische Universiteit Eindhoven / Maria Morant, Universitat Politècnica de València / Eduward Tangdiongga, Technische Universiteit Eindhoven / Ton Koonen, Technische Universiteit Eindhoven / Roberto Llorente, Universitat Politècnica de València

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11:00 - 11:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE8

Exhibit Hall Event - OSA Booth, Tech Talk: Optics to Scale the Datacenter Network

11:00 - 13:00 Pacific Time (US & Canada) (UTC - 07:00)

M4A

Special Session: Free Space Optical (FSO) Communication is Finally Real (Part 1)

Presider: Harald Haas

M4A.1

Taara Wireless Optical Communications (WOC) for Next-Generation Wireless Connectivity

Invited

Presenter: Baris Erkmen , *X (formerly Google[x]*

We will introduce Taara's Wireless Optical Communications (WOC) technology for terrestrial broadband networks. Our talk will focus on the technology pillars of our design that have allowed us to balance performance with cost-effective manufacturing.

Authors:Baris Erkmen, X (formerly Google[x]

M4A.2

The Coming Ascendancy of FSO Communication

Invited

Presenter: Mustafa Veziroglu , *SA Photonics*

Compelling market need from both commercial and military applications, coupled with maturing FSO technology and affordable, highly manufacturable architectures is finally driving the rapid adoption of this leading-edge communications technology.

Authors:Mustafa Veziroglu, SA Photonics

M4A.3

Optical Crosslinks for Data Relay in Low Earth Orbit

Invited

Presenter: Tim Yarnall , *MIT-LL*

Commercial high-rate LEO data relay networks with lasercom crosslink technology are nearing fruition. Physical layer connections are demonstrated, but higher layer challenges remain: topology control, data Doppler shifts, and disruption management.

Authors:Tim Yarnall, MIT-LL

M4A.4

Integrated Photonic Antenna Arrays for Imaging, Sensing and Communication

Invited

Presenter: Firooz Aflatouni , *University of Pennsylvania*

A review of our work on integrated electronic-photonics systems including LiDAR arrays for 3D imaging, laser phased arrays, and 2D optical phased arrays with off-aperture phase adjustment is presented.

Authors:Firooz Aflatouni, University of Pennsylvania

12:00 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE9

Exhibit Hall Event - OSA Booth, Tech Talk: Fiber Communication Networks - Telecom vs. Datacom

13:00 - 15:00 Pacific Time (US & Canada) (UTC - 07:00)

M5A

Integrated Photonics Devices and Systems

Presider: Hanxing Shi

M5A.1

Overview and Future Challenges on III-v Laser Integration Technologies in Silicon Photonics Platform

Invited

Presenter: Richard Jones , *Intel Corporation*

An overview of the work done at Intel Corporation on III-V integration with silicon photonics will be given, and future areas of development discussed.

Authors:Richard Jones, Intel Corporation

M5A.2

Hybrid III-v Laser Integration on a Monolithic Silicon Photonic Platform

Presenter: Yusheng Bian , *GLOBALFOUNDRIES*

We report a hybrid flip-chip-integrated laser attach technology on a monolithic SiPh platform. Efficient laser-to-PIC butt-coupling with optical power up to 11dBm was demonstrated through a combination of precise mechanical stops and optical alignment features.

Authors:Yusheng Bian, GLOBALFOUNDRIES / Koushik Ramachandran, GLOBALFOUNDRIES / Bo Peng, GLOBALFOUNDRIES / Brittany Hedrick, GLOBALFOUNDRIES / Scott Mills, GLOBALFOUNDRIES / Keith Donegan, GLOBALFOUNDRIES / Armand Rundquist, Neophotonics / Ed Vail, Neophotonics / Vaishnavi Karra, GLOBALFOUNDRIES / Firat Yasar, GLOBALFOUNDRIES / Monica Esopi, GLOBALFOUNDRIES / Benjamin Fasano, GLOBALFOUNDRIES / Asli Sahin, GLOBALFOUNDRIES / Thomas Houghton, GLOBALFOUNDRIES / Karen Nummy, GLOBALFOUNDRIES / Hanyi Ding, GLOBALFOUNDRIES / Takako Hirokawa, GLOBALFOUNDRIES / Kevin Dezfulian, GLOBALFOUNDRIES / Zhuojie Wu, GLOBALFOUNDRIES / Daniel Fisher, GLOBALFOUNDRIES / Jim Pape, GLOBALFOUNDRIES / Jay Steffes, GLOBALFOUNDRIES / Louis Medina, GLOBALFOUNDRIES / Subharup Roy, GLOBALFOUNDRIES / Harry Cox, GLOBALFOUNDRIES / Bart Green, GLOBALFOUNDRIES / Jorge Lubguban, GLOBALFOUNDRIES / Wonsuk Lee, GLOBALFOUNDRIES / Abdelsalam Aboketaf, GLOBALFOUNDRIES / Michal Rakowski, GLOBALFOUNDRIES / Kate Mclean, GLOBALFOUNDRIES / Zoey Sowinski, GLOBALFOUNDRIES / Oh-jung Kwon, GLOBALFOUNDRIES / Gabrielle Robert, GLOBALFOUNDRIES / Massimo sorbara, GLOBALFOUNDRIES / Subramanian Krishnamurthy, GLOBALFOUNDRIES / Jaekyu Cho, GLOBALFOUNDRIES / ian Melville, GLOBALFOUNDRIES / Dave Riggs, GLOBALFOUNDRIES / Rod Augur, GLOBALFOUNDRIES / Andy Stricker, GLOBALFOUNDRIES / Norman Robson, GLOBALFOUNDRIES / Daniel Berger, GLOBALFOUNDRIES / Luke Lee, GLOBALFOUNDRIES / Vikas Gupta, GLOBALFOUNDRIES / Anthony Yu, GLOBALFOUNDRIES / Ken Giewont, GLOBALFOUNDRIES / Ted Letavic, GLOBALFOUNDRIES / John Pellerin, GLOBALFOUNDRIES

M5A.3

Record High Power Single-Mode Operation and Beam Steering of VCSEL-Integrated Amplifier/Beam Scanner

Presenter: SHANTING HU , *Tokyo Institute of Technology*

We demonstrate single-mode surface-grating VCSEL-integrated amplifier/beam scanner. We obtained the record single-mode output-power over 3W under pulsed operations. A continuous fan-beam steering of 5° and 70 resolution points are achieved.

Authors:SHANTING HU, Tokyo Institute of Technology / Xiaodong Gu, Tokyo Institute of Technology / Ahmed Hassan, Tokyo Institute of Technology / Masanori Nakahama, Tokyo Institute of Technology / Satoshi Shinada, National Institute of Information and Communications Technology / Fumio Koyama, Tokyo Institute of Technology

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M5A.4

Record Performance of 53GB Ge/Si Avalanche Photodiode ROSA

Presenter: Bin Shi , *SiFotonics Technologies Co., Ltd.*

53GB Ge/Si APD TO-CAN ROSA were designed and fabricated with record breaking sensitivities of -23.2dBm at BER=1E-3 for 53GB NRZ and -16.0dBm at BER=2E-4 for 53GB PAM4, respectively.

Authors:Bin Shi, SiFotonics Technologies Co., Ltd. / Yanhui Duan, SiFotonics Technologies Co., Ltd. / Fan Qi, SiFotonics Technologies Co., Ltd. / Pengfei Cai, SiFotonics Technologies Co., Ltd. / Xueping Chen, SiFotonics Technologies Co., Ltd. / Zhenhua Wei, SiFotonics Technologies Co., Ltd. / Guanghui Hou, SiFotonics Technologies Co., Ltd. / Tzungi Su, SiFotonics Technologies Co., Ltd. / Su Li, SiFotonics Technologies Co., Ltd. / Wang Chen, SiFotonics Technologies Co., Ltd. / Chingyin Hong, SiFotonics Technologies Co., Ltd. / Dong Pan, SiFotonics Technologies Co., Ltd.

M5A.5

>25 Gbit/s LiFi With Laser Based SMD White Light Source

Invited

Presenter: James Raring , *Kyocera SLD Laser*

We demonstrate high-speed LiFi communication with ultra-high brightness laser-based white light sources. The sources provide up to 1000 lm of white light output, over 1000 cd/mm^2 of brightness, and data rates beyond 25 Gbit/s.

Authors:James Raring, Kyocera SLD Laser / Changmin Lee, Kyocera SLD Laser / Mohamed Sufyan Islim, University of Strathclyde / Stefan Videv, University of Strathclyde / Adrian Sparks, University of Strathclyde / Melvin McLaurin, Kyocera SLD Laser / Binith Shah, Kyocera SLD Laser / Paul Rudy, Kyocera SLD Laser / Harald Haas, University of Strathclyde

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M5B

Nonlinear Optical Devices

Presider: Francesca Parmigiani

M5B.1

Neuromorphic Photonics for Optical Communication Systems

Invited

Presenter: Chaoran Huang , *Princeton University*

Neuromorphic photonics creates processors 1000× faster than electronics while consuming less energy. We will discuss the role of neuromorphic photonics in optical communications, review existing approaches, and outline the required technologies to evolve this field.

Authors:Chaoran Huang, Princeton University / Thomas Ferreira de Lima, Princeton University / Shinsuke Fujisawa, NEC Laboratories America, Inc / Alexander Tait, Princeton University / hsuan-tung peng, Princeton University / Bhavin Shastri, Queens University / Ting Wang, NEC Laboratories America, Inc / Paul Prucnal, Princeton University

M5B.2

Wideband PPLN-Based Optical Parametric Amplifiers for Scalable Optical Transport Network

Invited

Presenter: Yutaka Miyamoto , *NTT Network Innovation Laboratories*

This paper reviews the wideband optical parametric amplifiers based on periodically poled $LiNbO_3$ (PPLN) waveguides for scalable optical transport network. The achievable bandwidth over 10 THz is promising to offset capacity crunch in today's network.

Authors:Yutaka Miyamoto, NTT Network Innovation Laboratories / Takayuki Kobayashi, NTT Network Innovation Laboratories / Takeshi Umeki, NTT Network Innovation Laboratories / Takushi Kazama, NTT Network Innovation Laboratories / Koji Enbutsu, NTT Device Technology Laboratories / Shimpei Shimizu, NTT Network Innovation Laboratories / Ryoichi Kasahara, NTT Device Technology Laboratories

M5B.3

Robust Polarization-Insensitive C & L Band FOPA With >17dB Gain for Both WDM and Bursty Traffic

Presenter: Vladimir Gordienko , *Aston University*

We demonstrate, for the first time, a real-time stabilized polarization-insensitive fiber optic parametric amplifier to simultaneously amplify WDM C&L band traffic in an extended-reach PON scenario with gain >17dB and output power >23 dBm.

Authors:Vladimir Gordienko, Aston University / Chandra Gaur, Aston University / Florent Bessin, Aston University / Ian Phillips, Aston University / Nick Doran, Aston University

M5B.4

Dual-Polarization C+L-Band Wavelength Conversion in a Twin-Core Highly Nonlinear Fibre

Presenter: Vitor Ribeiro , *Aston Institute of Photonics Technologies, Aston University*

All-optical wavelength conversion of dual-polarization signals over 9.6 nm in C+L-band is demonstrated in a twin-core highly nonlinear fibre for the first time. Conversion efficiencies between -1 dB and -8.5 dB for both cores are obtained simultaneously.

Authors:Aron Szabo, Aston Institute of Photonics Technologies, Aston University / Vitor Ribeiro, Aston Institute of Photonics Technologies, Aston University / Chandra Gaur, Aston Institute of Photonics Technologies, Aston University / Abdallah Ali, Aston Institute of Photonics Technologies, Aston University / Arnaud Mussot, Univ. Lille, CNRS / Yves Quiquempois, Univ. Lille, CNRS / Geraud Bouwmans, Univ. Lille, CNRS / Nick Doran, Aston Institute of Photonics Technologies, Aston University

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M5B.5

Parametric Frequency Comb Generation Using Silicon Core Fiber

Presenter: Ronit Sohanpal , *University College London*

We demonstrate all-fiber frequency comb generation using a 10-mm-length silicon core fiber as the parametric mixer. We achieved 8 dB spectral flatness over 20 nm bandwidth, generating 90 lines at 26 GHz line spacing.

Authors:Ronit Sohanpal, University College London / Haonan Ren, University of Southampton / Li Shen, Huazhong University of Science and Technology / Callum Deakin, University College London / Alexander Heidt, University of Bern / Thomas Hawkins, Clemson University / John Ballato, Clemson University / Ursula Gibson, Norwegian University of Science and Technology / Anna Peacock, University of Southampton / Zhixin Liu, University College London

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M5B.6

Nonlinear Fourier Transform Enabled Multiple Pulses Purification for Soliton Communication

Presenter: Yutian Wang , *HUST*

Nonlinear Fourier transform (NFT) enabled soliton distillation is exploited to purify multiple pulses from an ultrafast fiber laser, which paves a way to manipulate the soliton separation and revives soliton communication.

Authors:Yutian Wang, HUST / Songnian Fu, Advanced Institute of Photonics Technology, School of Information Engineering, and Guangdong Provincial Key Laboratory of Information Photonics Technology / Ming Tang, HUST / Chi Zhang, HUST / Xiahui Tang, HUST / Jian Kong, Kunshan Shunke Laser Technology Co., Ltd / Luming Zhao, HUST

M5C

Transmission Systems Modeling

Presider: Rene-Jean Essiambre

M5C.1

A Closed-Form Nonlinearity Model for Forward-Raman-Amplified WDM Optical Links

Presenter: Mahdi Ranjbar Zefreh , *Politecnico di Torino*

We propose an accurate nonlinearity closed-form model (CFM) for forward Raman-amplified WDM links which enables fast system optimization. We show a detailed study of a single-span link SNR maximization and flattening.

Authors:Mahdi Ranjbar Zefreh, Politecnico di Torino / Fabrizio Forghieri, Cisco Photonics / Stefano Piciaccia, Cisco Photonics / Pierluigi Poggiolini, Politecnico di Torino

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M5C.2

Modeling of Nonlinear Interference Power for Dual-Polarization 4D Formats

Presenter: Gabriele Liga , *Eindhoven University of Technology*

We assess the accuracy of a recently introduced nonlinear interference model for general dual-polarization 4D formats. Unlike previous models for polarization-multiplexed 2D formats, an average gap from split-step Fourier simulations within 0.1 dB is demonstrated.

Authors:Gabriele Liga, Eindhoven University of Technology / Bin Chen, Hefei University of Technology / Astrid Barreiro, Eindhoven University of Technology / Alex Alvarado, Eindhoven University of Technology

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M5C.3

Impact of Crosstalk on 800 Gb/s 90 GBaud 64QAM Channel

Presenter: Thierry Zami , *Nokia Corporation*

We experimentally investigate and model how optical in-band crosstalk impairs 200 Gb/s QPSK, 300 Gb/s PCS-16QAM as well as 400 Gb/s 16QAM 68 GBaud WDM carriers, and eventually 90 GBaud 800 Gb/s 64QAM channels.

Authors:Thierry Zami, Nokia Corporation / Kaoutar Benyahya, Nokia Corporation / Aymeric Arnould, Nokia Corporation / Haik Mardoyan, Nokia Corporation / Jeremie Renaudier, Nokia Corporation / Bruno Lavigne, Nokia Corporation

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M5C.4

Highly Accurate Measurement-Based Gain Model for Constant-Pump EDFA With non-Flat WDM Inputs

Presenter: Alexis Carbó Meseguer , *Alcatel Submarine Networks*

We develop a simple and accurate measurement-based model to predict the gain of wideband erbium-doped fiber amplifiers with a root mean square error of 0.05 dB, lower than state-of-the-art models based on machine learning techniques.

Authors:Alexis Carbó Meseguer, Alcatel Submarine Networks / Jean-Christophe Antona, Alcatel Submarine Networks / Alberto Bononi, Università di Parma / Junho Cho, Nokia Bell Labs / Stephen Grubb, Facebook / Pascal Pecci, Alcatel Submarine Networks / Olivier Courtois, Alcatel Submarine Networks / Vincent Letellier, Alcatel Submarine Networks

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M5C.5

Application of Perturbation Theory in the Performance Analysis of Fiber-Optic Transmission Systems

Tutorial

Presenter: Amirhossein Ghazisaeidi , *Nokia Bell Labs France*

We will review the fundamentals of the perturbative analysis of the performance of fiber-optic coherent transmission systems and address some recent advances in modeling nonlinear signal-noise interactions, and inclusion of amplifier physics.

Authors:Amirhossein Ghazisaeidi, Nokia Bell Labs France

M5D
Panel: Deployment Challenges of 400G Optics and Beyond

M5E
Advanced Detection and Fibers

Presider: Hisao Nakashima

M5E.1

Quantum Limits in Optical Communications

Tutorial

Presenter: Konrad Banaszek , *Uniwersytet Warszawski*

The Gordon-Holevo capacity limit is reviewed as a unifying framework to identify attainable information rates in a variety of optical communication scenarios as well as a tool to analyze the security of quantum key distribution.

Authors:Konrad Banaszek, Uniwersytet Warszawski

M5E.2

Recent Breakthroughs in Hollow Core Fiber Technology

Invited

Presenter: Gregory Jasion , *Optoelectronics Research Centre*

The performance of Hollow Core Fibers has improved dramatically over the last 6 years. We report progress of the most successful design, Nested Antiresonant Nodeless Fiber, with losses of 0.28 dB/km.

Authors:Gregory Jasion, Optoelectronics Research Centre / Thomas Bradley, Optoelectronics Research Centre / Kerrianne Harrington, Optoelectronics Research Centre / Hesham Sakr, Optoelectronics Research Centre / Yong Chen, Optoelectronics Research Centre / Eric Rodrigue Numkam Fokoua, Optoelectronics Research Centre / Ian Davidson, Optoelectronics Research Centre / Austin Taranta, Optoelectronics Research Centre / John Hayes, Optoelectronics Research Centre / David Richardson, Optoelectronics Research Centre / Francesco Poletti, Optoelectronics Research Centre

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M5E.3

Record-Low-Loss 83 μm^2 Effective Area Fiber and Transmission of 40x369 Gb/s Channels Over a Trans-Atlantic Submarine Link With 101 km Spans

Presenter: Xiaojun Liang , *Corning Inc*

We present optical fiber with 83 μm^2 effective area and record-low attenuation of 0.1522 dB/km. We conduct experiments with 404 km of fiber in 101 km spans, demonstrating trans-Atlantic system transmission with 369 Gb/s channels.

Authors:John Downie, Corning Inc / Xiaojun Liang, Corning Inc / Jason Hurley, Corning Inc / Hazel Matthews, Corning Inc / Darren Stainer, Corning Inc / Sergejs Makovejs, Corning Inc / Dana Smith, Corning Inc

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M5F

Machine Learning for Optical Subsystems

Presider: Hussam Batshon

M5F.1

Nonlinear Impairment Compensation Using Neural Networks

Invited

Presenter: Fatih Yaman , *NEC Laboratories America Inc*

Neural networks are attractive for nonlinear impairment compensation applications in communication systems. In this paper, several approaches to reduce computational complexity of the neural network-based algorithms are presented

Authors:Shinsuke Fujisawa, NEC Laboratories America Inc / Fatih Yaman, NEC Laboratories America Inc / Hussam Batshon, NEC Laboratories America Inc / Massaki Tanio, NEC Corporation / Naoto Ishii, NEC Corporation / Chaoran Huang, Princeton University / Thomas Ferreira de Lima, Princeton University / Yoshihisa Inada, NEC Corporation / Paul Prucnal, Princeton University / Norifumi Kamiya, NEC Corporation / Ting Wang, NEC Laboratories America Inc

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M5F.2

54.5 Tb/s WDM Transmission Over Field Deployed Fiber Enabled by Neural Network-Based Digital Pre-Distortion

Presenter: Vinod Bajaj , *Nokia Bell-Labs*

We demonstrate a record 54.5 Tb/s WDM transmission at 11.35 bit/s/Hz over 48 km of field-deployed SMF connecting business and academic parks enabled by a novel joint I-Q Neural Network-based transmitter digital pre-distortion technique.

Authors:Vinod Bajaj, Nokia Bell-Labs / Fred Buchali, Nokia Bell-Labs / Mathieu Chagnon, Nokia Bell-Labs / Sander Wahls, Delft University of Technology / Vahid Aref, Nokia Bell-Labs

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M5F.3

Neural Network Training Framework for Nonlinear Signal-to-Noise Ratio Estimation in Heterogeneous Optical Networks

Presenter: Aazar Saadaat Kashi , *Queen's University*

A computationally efficient framework is presented for calculating features used for training an ANN-based estimator of the nonlinear SNR in heterogeneous networks. Its efficacy is demonstrated using data computed for 153,576 distinct system configurations.

Authors:Aazar Saadaat Kashi, Queen's University / John Cartledge, Queen's University / Wai-Yip Chan, Queen's University

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M5F.4

Recurrent Neural Network Soft Demapping for Mitigation of Fiber Nonlinearities and ISI

Presenter: Maximilian Schaedler , *Huawei Technologies*

Optical transmission systems suffer from linear and nonlinear impairments induced by components and fibers. As countermeasures, neural network soft-demappers are proposed and benchmarked against combinations of digital back-propagation, Volterra equalizers, noise whitening and soft-output Viterbi-algorithms.

Authors:Maximilian Schaedler, Huawei Technologies / Fabio Pittala, Huawei Technologies / Stefano Calabro, Huawei Technologies / Georg Böcherer, Huawei Technologies / Christian Bluemm, Huawei Technologies / Stephan Pachnicke, Kiel University (CAU)

M5F.5

Hardware-Efficient Nonlinear Equalizer Based on Joint Unsupervised Learning and Supervised Weights

Presenter: Zheng Yang , *School of Optical and Electronic Information, Huazhong University of Science and Technology*

We propose a hardware-efficient Volterra filter equalizer (VFE) based on the weighted principal component analysis (WPCA). 60% taps of traditional VFE are saved without receiver sensitivity penalty for 56-Gb/s PAM-4 transmission over 100-km SSMF.

Authors:Zheng Yang, School of Optical and Electronic Information, Huazhong University of Science and Technology / Songnian Fu, Guangdong University of Technology / Ming Tang, School of Optical and Electronic Information, Huazhong University of Science and Technology / Yuncai Wang, Guangdong University of Technology / Yuwen Qin, Guangdong University of Technology

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M5F.6

Kernel-Based Learning-Aided Phase Noise Compensation in Dual-Pump Optical Phase Conjugation Coherent System

Presenter: Sonia Boscolo , *Aston University, Aston Institute of Photonic Technologies*

We deploy kernel-based time-series prediction to suppress the phase noise induced by small deviations from ideal pump counter-phasing in a dual-pump optical phase conjugation system. We show experimentally 1.5-dB SNR improvement for 16-QAM signals at 4^{o} pump-phase mismatch.

Authors:Tu Nguyen, Aston University, Aston Institute of Photonic Technologies / Sonia Boscolo, Aston University, Aston Institute of Photonic Technologies / Abdallah Ali, Aston University, Aston Institute of Photonic Technologies / Mingming Tan, Aston University, Aston Institute of Photonic Technologies / Tingting Zhang, Aston University, Aston Institute of Photonic Technologies / Shigehiro Takasaka, Furukawa Electric / Ryuichi Sugizaki, Furukawa Electric / Stylianos Sygletos, Aston University, Aston Institute of Photonic Technologies / Andrew Ellis, Aston University, Aston Institute of Photonic Technologies

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M5G

Coherent for Data-center Applications: DSP

Presider: Stephen Ralph

M5G.1

Performance Oriented DSP Design for Flexible Coherent Transmission for Data Center Networks

Tutorial

Presenter: Han Henry Sun , *Infinera Corporation*

Today's long haul transmission network requires the highest performance in the physical layer. This tutorial discusses the challenges and techniques in designing a high performance DSP that also obeys complexity and implementation constraints.

Authors:Han Henry Sun, Infinera Corporation

M5G.3

Simplest DSP in Self-Homodyne Coherent Transmission Using Bidirectional Adaptive Polarization Controller

Presenter: Wang Li , *Huazhong University of Science and Techn*

We propose and develop bidirectional adaptive polarization tracking and compensation for counterpropagating LO and signal in the same fiber respectively. A simplest MIMO-free DSP is achieved in the self-homodyne coherent transmission under dynamic SOP rotation.

Authors:Wang Li, Huazhong University of Science and Techn / Yizhao Chen, Huazhong University of Science and Techn / Xuefeng Wang, Huazhong University of Science and Techn / Can Zhao, Huazhong University of Science and Techn / Junda Chen, Huazhong University of Science and Techn / Ming Tang, Huazhong University of Science and Techn

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M5G.4

Cost-Effective and Hardware-Efficient Coherent Scheme for 400G Short-Reach Transmission

Presenter: Tingting Zhang , *Huawei Technologies Co. Ltd.*

We propose and experimentally demonstrate a 400G coherent-lite scheme for 2-km transmission with a DFB laser. Carrier-recovery-free D8QAM achieves comparable performance as 16QAM and the proposed AEQ has 40% lower complexity than conventional MIMO.

Authors:Tingting Zhang, Huawei Technologies Co. Ltd. / Qian Xiang, Huawei Technologies Co. Ltd. / Sen Zhang, Huawei Technologies Co. Ltd. / Lei Liu, Huawei Technologies Co. Ltd. / Tianjian Zuo, Huawei Technologies Co. Ltd.

M5G.2

Interoperable Coherent Optics for Extended Reach - Assisting Data Center Evolution

Invited

Presenter: Atul Srivastava , *NEL-America*

An overview of coherent 400ZR and OpenZR+ modules and interoperability test results are presented. Role of Coherent in future 800G and higher rate modules is discussed.

Authors:Atul Srivastava, NEL-America

13:00 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

SC102

Short Course - SC102 - WDM in Long-Haul Transmission Systems

SC431

Short Course - SC431 - Photonic Technologies in the Data Center

SC451

Short Course - SC451 - Optical Fiber Sensors

13:30 - 15:30 Pacific Time (US & Canada) (UTC - 07:00)

M6A

Special Session: Free Space Optical (FSO) Communication is Finally Real (Part 2)

Presider: Harald Haas

M6A.1

High Speed MEMS Beamforming for FSO

Invited

Presenter: Stephen Hamann , *Silicon Light Machines*

We will examine the benefits of beam forming for free space optical communication, demonstrate our available and upcoming MEMS technologies, as well as review many of the extant integrated and other technologies available right now.

Authors:Stephen Hamann, Silicon Light Machines

M6A.2
Taking LiFi Mainstream
Invited

Presenter: Alistair Banham , *pureLiFi Ltd.*

Mainstream LiFi is just on the horizon. Using light instead of radio waves to send and receive data, LiFi's security, safety and bandwidth advantages make it the right solution at the right time.

Authors:Alistair Banham, pureLiFi Ltd.

M6A.3
LiFi is Here
Invited

Presenter: Musa Unmehopa , *Signify*

LiFi is here. Following the first commercial deployments, a growing ecosystem is taking shape, forming the boundary conditions for market growth. Industry alliances, standardization, and interoperability certification are presented as key enablers for this growth.

Authors:Musa Unmehopa, Signify

M6A.4
LiFi at the Heart of Future Intelligent Communications Networks
Invited

Presenter: Micheline Perrufel , *Orange Labs*

Digital wireless technologies have revolutionized our communication habits but still have too limited convergence. Tomorrow, LiFi will accompany, alongside 5G, Fiber & Wi-Fi, exponential data consumption, but will require to redesign a more fluid, secured and intelligent global framework.

Authors:Micheline Perrufel, Orange Labs

14:00 - 14:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE10

Exhibit Hall Event - OSA Booth, Tech Talk: High-Speed Semiconductor Lasers and Modulators for Data Communications

14:00 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

SC114

Short Course - SC114 - Technologies and Applications for Passive Optical Networks (PONs)

SC359

Short Course - SC359 - Datacenter Networking 101

SC464

Short Course - SC464 - Software Defined Networking in the Cloud - Designs, Operations, and Management

SC486

Short Course - SC486 - Optoelectronic Devices for LIDAR and High-BW or 3D Sensing

15:30 - 16:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC3

Exhibit Hall Event - Technology Showcase: Leveraging QSFP-DD and ZR/ZR+ in Networking Platforms

15:30 - 19:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

16:00 - 16:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC4

Exhibit Hall Event - Technology Showcase: Cloud Metro New Metro Architectures for 5G, IoT, and Low Latency Services

16:30 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC5

Exhibit Hall Event - Technology Showcase: Guaranteed Network Service Levels with Paragon Active Assurance

17:00 - 21:00 Pacific Time (US & Canada) (UTC - 07:00)

SC178

Short Course - SC178 - Test and Measurement for Data Center/Short Reach Communications

SC487

Short Course - SC487 - Hands-On: Laboratory Automation and Control using Python (Advanced)

17:30 - 18:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC6

Exhibit Hall Event - Technology Showcase: Industry Trends and the Test Ramifications

18:00 - 18:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC7

Exhibit Hall Event - Technology Showcase: Optical Trends in Metro/Access Networks

18:00 - 21:00 Pacific Time (US & Canada) (UTC - 07:00)

SC408

Short Course - SC408 - Space Division Multiplexing for Optical Communication Systems and Networks

18:30 - 19:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC8

Exhibit Hall Event - Technology Showcase: New Developments in Ultra High-Resolution Fiber Optic Testing

Tuesday, 08 June

3:00 - 5:00 Pacific Time (US & Canada) (UTC - 07:00)

Tu1A

Symposia: On the Edge: MEC- based Network Architectures in Support of Enterprise Cloud (Part 1)

Presider: Reza Nejabati

Tu1A.1

Edge-Based 5G Network Architectures in Support of Zero Downtime Mobility for Enterprise Applications

Invited

Presenter: Dan Warren , *Samsung*

Ultra-Reliable Low Latency 5G applications require Edge implementation deep in access networks, resulting in the need for inter-Edge Server application mobility. This paper identifies implementation methodology for zero-downtime Edge application mobility.

Authors:Dan Warren, Samsung / Xenofon Vasilakos, University of Bristol Smart Internet Lab / Walter Featherstone, Samsung

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Tu1A.2

Accelerating 5G Enterprise Networks With Edge Computing and Latency Assurance

Invited

Presenter: Jim Zou , *ADVA Optical Networking SE*

Abstract not available.

Authors:Jim Zou, ADVA Optical Networking SE

Tu1A.3

MEC and Fixed Access Networks Synergies

Invited

Presenter: Gael Simon , *Orange Labs*

Both multi-access edge computing and fixed access networks are experiencing tremendous evolutions. We propose here to discuss their synergies, focusing on the needs for industry.

Authors:Gael Simon, Orange Labs / Philippe Chanclou, Orange Labs / Minqi Wang, Orange Labs / Luiz Anet Neto, IMT Atlantique / Anas El Ankouri, Orange Labs / Fabienne Saliou, Orange Labs / Jeremy Potet, Orange Labs

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Tu1A.4

Open and Disaggregated Networks as Enablers for Opportunities at the Edge

Invited

Presenter: David Hutton , *TIP*

Abstract not available.

Authors:David Hutton, TIP

Tu1B

Tutorials on Advanced Directly-modulated Lasers

Presider: Hideyuki Nasu

Tu1B.1

High Speed VCSEL Technology and Applications

Tutorial

Presenter: Nikolay Ledentsov , *VI Systems GmbH*

We report on recent advances in vertical cavity surface emitting lasers (VCSELs). Modern VCSELs enable multiple applications in sensing and in data communication, where they operate at speeds of up to 224Gb/s per single chip.

Authors:Nikolay Ledentsov, VI Systems GmbH

Tu1B.2

Direct Modulation of Membrane Distributed Reflector Lasers Using Optical Feedback

Invited

Presenter: Shinji Matsuo , *NTT Device Technology Labs*

We have developed directly modulated membrane distributed reflector lasers using optical feedback from a DBR or an external waveguide. High-speed modulation with low power consumption is achieved due to photon-photon resonance and detuned loading effects.

Authors:Shinji Matsuo, NTT Device Technology Labs / Nikolaos-Panteleimon Diamantopoulos, NTT Device Technology Labs / Suguru Yamaoka, NTT Device Technology Labs / Hidetaka Nishi, NTT Device Technology Labs

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Tu1B.3

Challenges and Opportunities of Directly Modulated Lasers in Future Data Center and 5G Networks

Invited

Presenter: Tsurugi Sudo , *II-VI Incorporated*

This talk aims to share a product development team's perspective on the maturity of the foundations of high-speed DMLs today and confidence in productizing DMLs for 100 Gb/s per wavelength and beyond tomorrow.

Authors:Tsurugi Sudo, II-VI Incorporated / Yasuhiro Matsui, II-VI Incorporated / Glen Carey, II-VI Incorporated / Ashish Verma, II-VI Incorporated / Ding Wang, II-VI Incorporated / Viral Lowalekar, II-VI Incorporated / Martin Kwakernaak, II-VI Incorporated / Ferdous Khan, II-VI Incorporated / Nicholas Dalida, II-VI Incorporated / Ronak Patel, II-VI Incorporated / Alexander Nickel, II-VI Incorporated / Bruce Young, II-VI Incorporated / Jimmy Zeng, II-VI Incorporated / Yuk Lung Ha, II-VI Incorporated / Charles Roxlo, II-VI Incorporated

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Tu1C

Polarization and Beam Splitting Optical Devices

Presider: Antonella Bogoni

Tu1C.1

High-Performance Polarization-Handling Devices on Silicon

Invited

Presenter: Daoxin Dai , *Zhejiang University*

Recent progresses for high-performance polarization-handling components on silicon are reported, including polarization-selective silicon photonic devices as well as photonic devices working with dual polarizations, which are very useful for various optical systems.

Authors:Daoxin Dai, Zhejiang University / Zhuoning Zhu, Zhejiang University

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Tu1C.2

Mode-Evolution-Based InP/InGaAsP Polarization Rotator With Etching-Stop Layer

Presenter: Ryota Tanomura , *The University of Tokyo*

We propose and experimentally demonstrate a monolithic InP/InGaAsP mode-evolution-based polarization rotator. Using the adiabatic mode transition inside a tapered half-ridge waveguide, fabrication-tolerant conversion with an efficiency over 97.7% is obtained over the entire C-band. <gdiv></gdiv>

Authors:Ryota Tanomura, The University of Tokyo / Abdulaziz Elfiqi, The University of Tokyo / Dawei Yu, Hisilicon OptoElectronics Co., Ltd. / Warakorn Yanwachirakul, The University of Tokyo / Haifeng Shao, Hisilicon OptoElectronics Co., Ltd. / Yuto Suzuki, The University of Tokyo / Takuo Tanemura, The University of Tokyo / Yoshiaki Nakano, The University of Tokyo

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Tu1C.3

Demonstration of an Integrated Photonic Magic T -- a Robust Beam Splitter and Novel Polarization Diversity Building Block

Presenter: MANUJ KUMAR SINGH , *BOSTON UNIVERSITY*

We demonstrate an adiabatic magic T in a 45nm CMOS photonics foundry platform, with 3+/-0.25 dB power splitting and <1.2 dB loss over 1530-1600nm, with a 60um long-device. It functions as a 2x2 beam splitter with splitting ratio from both input ports fundamentally robust by symmetry, and supports novel polarization diversity and modulator designs.

Authors:MANUJ KUMAR SINGH, BOSTON UNIVERSITY / Josep Fargas Cabanillas, BOSTON UNIVERSITY / Dorde Gluhovic, BOSTON UNIVERSITY / Bohan Zhang, BOSTON UNIVERSITY / Milos Popovic, BOSTON UNIVERSITY

Tu1C.4

High-Performance Silicon Quadplexer for Passive Optical Networks

Presenter: Dajian Liu , *Zhejiang University*

We realized the first silicon quadplexer with low excess losses of ~0.5 dB and the desired bandwidths (i.e., 16/38/19/6 nm) for the wavelength-channels of 1270/1310/1490/1577 nm using multimode-waveguide-grating-based filters.

Authors:Dajian Liu, Zhejiang University / Long Zhang, Zhejiang University / Hexin Jiang, Zhejiang University / Daoxin Dai, Zhejiang University

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Tu1C.6

A Silicon Nitride Reconfigurable Linear Optical Processor

Presenter: Lorenzo De Marinis , *Scuola Superiore Sant'Anna*

The characterization of a broadband Si_3N_4 integrated linear optical processor operating in the C-Band is reported. The impact of losses on the processor accuracy is discussed towards the photonic implementation of state-of-the-art neural networks.

Authors:Lorenzo De Marinis, Scuola Superiore Sant'Anna / Giampiero Contestabile, Scuola Superiore Sant'Anna / Piero Castoldi, Scuola Superiore Sant'Anna / Nicola Andriolli, National Research Council of Italy

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Tu1C.7

Integrated-Optic Gate-Free Tunable Filter for Demultiplexing Various Channel Symbol Rate OFDM Signals

Presenter: Koichi Takiguchi , *Ritsumeikan University*

We demonstrate a tunable OFDM filter that comprises a star coupler-based Fourier transformation circuit and functions without optical gates. Various channel symbol-rate signals (5 x 10 and 20 Gsymbol/s) were successfully demultiplexed with the filter.

Authors:Koichi Takiguchi, Ritsumeikan University / Hideaki Masaki, Ritsumeikan University

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Tu1C.5

Ultra-Compact and Broadband 3-dB Power Splitter Based on Subwavelength Grating at 2-μm

Presenter: Zelu Wang , *Harbin Institute of Technology*

We demonstrate a 3-dB power splitter based on subwavelength grating waveguides. The devices footprint is only 3μm×2 μm. The insertion loss is < 0.3 dB and the bandwidth exceeds 55 nm at 2-μm waveband.

Authors:Zelu Wang, Harbin Institute of Technology / Yingjie Liu, Harbin Institute of Technology / Shuai Wang, Harbin Institute of Technology / Yilin Liu, Harbin Institute of Technology / Jiangbing Du, Shanghai Jiao Tong University / Qinghai Song, Harbin Institute of Technology / Ke Xu, Harbin Institute of Technology

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Tu1D
High-speed Transmitters

Presider: Argishti Melikyan

Tu1D.1

224-Gb/s PAM4 Uncooled Operation of Lumped-Electrode EA-DFB Lasers With 2-km Transmission for 800GbE Application

Presenter: Syunya Yamauchi , *Lumentum Japan, Inc.*

Newly developed lumped-electrode (LE) EA-DFB lasers demonstrated 224-Gb/s PAM4 uncooled operation with 2-km transmission. Its average output power and TDECQ from 20 to 80°C are respectively more than 6 dBm and less than 2.8 dB.

Authors:Syunya Yamauchi, Lumentum Japan, Inc. / Koichiro Adachi, Lumentum Japan, Inc. / Hideaki Asakura, Lumentum Japan, Inc. / Hayato Takita, Lumentum Japan, Inc. / Yoshihiro Nakai, Lumentum Japan, Inc. / Yoriyoshi Yamaguchi, Lumentum Japan, Inc. / Masatoshi Mitaki, Lumentum Japan, Inc. / Ryosuke Nakajima, Lumentum Japan, Inc. / Shigehisa Tanaka, Lumentum Japan, Inc. / Kazuhiko Naoe, Lumentum Japan, Inc.

Tu1D.2

High-Power low-Modulating-Voltage 1.5 µm-Band CWDM Uncooled EMLs for 800 Gb/s (53.125 Gbaud-PAM4) Transceivers

Presenter: Shinya Okuda , *MITSUBISHI ELECTRIC Corporation*

Uncooled 53 Gbaud-PAM4 operation of 1.5 µm-band CWDM EMLs were demonstrated. A hybrid waveguide structure was designed to enhance output power, bandwidth, and extinction ratio with a low modulating voltage.

Authors:Shinya Okuda, MITSUBISHI ELECTRIC Corporation / Takeshi Yamatoya, MITSUBISHI ELECTRIC Corporation / Tsutomu Yamaguchi, MITSUBISHI ELECTRIC Corporation / Yusuke Azuma, MITSUBISHI ELECTRIC Corporation / Yoshikazu Tanaka, MITSUBISHI ELECTRIC Corporation

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Tu1D.3

60Gb/s Waveguide-Coupled O-Band GeSi Quantum-Confined Stark Effect Electro-Absorption Modulator

Presenter: Srinivasan Ashwyn Srinivasan , *Interuniversity Microelectronics Center*

We report O-band GeSi quantum-confined Stark effect waveguide-coupled electro-absorption modulator with 50GHz bandwidth. Static extinction ratio of 5.2dB, insertion loss of 7.6dB and 60Gb/s NRZ-OOK operation are shown for a 2V swing.

Authors:Srinivasan Ashwyn Srinivasan, Interuniversity Microelectronics Center / Clement Porret, Interuniversity Microelectronics Center / Sadhishkumar Balakrishnan, Interuniversity Microelectronics Center / Yoojin Ban, Interuniversity Microelectronics Center / Roger Loo, Interuniversity Microelectronics Center / Peter Verheyen, Interuniversity Microelectronics Center / Joris Van Campenhout, Interuniversity Microelectronics Center / Marianna Pantouvaki, Interuniversity Microelectronics Center

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Tu1D.4

106-Gb/s PAM4 Operation of Directly Modulated DFB Lasers From 25 to 70°C for Transmission Over 2-km SMF in the CWDM Range

Presenter: Takayuki Nakajima , *Lumentum Japan, Inc.*

Four directly modulated DFB lasers with 1.3-μm CWDM range demonstrated 106-Gb/s PAM4 operation for transmission over 2-km SMF. Dispersion penalties of the lasers were less than 0.8 dB after 2-km transmission up to 70°C.

Authors:Takayuki Nakajima, Lumentum Japan, Inc. / Masaru Onga, Lumentum Japan, Inc. / Yuji Sekino, Lumentum Japan, Inc. / Akira Nakanishi, Lumentum Japan, Inc. / Noriko Sasada, Lumentum Japan, Inc. / Shigenori Hayakawa, Lumentum Japan, Inc. / Shigetaka Hamada, Lumentum Japan, Inc. / Kazuhiko Naoe, Lumentum Japan, Inc.

Tu1D.5

Ultra-Wide Bandwidth Thin-Film $LiNbO_3$ Modulator With Record-Low Half-Wave-Voltage Length Product

Presenter: Xuecheng Liu , *Tsinghua University*

Novel electro-optic modulators are fabricated based on $LiNbO_3$-silica hybrid waveguide and capacitively-loaded electrodes. Record-low half-wave-voltage length product of 1.7 V*cm and modulation bandwidth > 67 GHz are demonstrated.

Authors:Xuecheng Liu, Tsinghua University / Bing Xiong, Tsinghua University / Changzheng Sun, Tsinghua University / Zhibiao Hao, Tsinghua University / Lai Wang, Tsinghua University / Jian Wang, Tsinghua University / Yanjun Han, Tsinghua University / Hongtao Li, Tsinghua University / Jiadong Yu, Tsinghua University / Yi Luo, Tsinghua University

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Tu1D.6

DAC-Less PAM-4 Slow-Light Silicon Photonic Modulator Assisted by Coupled Bragg Grating Resonators

Presenter: Omid Jafari , *Universite Laval*

We report a slow-light all-silicon modulator with two segmented electrodes that enables high-speed-PAM operations and simultaneously meets all requirements of high bandwidth (>40GHz), power-efficient operation (73fJ/bit), compact footprint ($L_{SL\text{-}MZM}$=570μm), and wide operating wavelength range ($\Delta\lambda$=2nm).

Authors:Omid Jafari, Universite Laval / Sasan Zhalehpour, Huawei Technologies Canada / Wei Shi, Universite Laval / Sophie LaRochelle, Universite Laval

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Tu1D.7

25-Gbit/s 100-km Transmission Using 1358-nm-Wavelength SOA Assisted Extended Reach EADFB Laser (AXEL) for 25 Gbit/s-Class PON

Presenter: Takahiko Shindo , *NTT Device innovation center*

25-Gbit/s non-return-to-zero (NRZ) transmissions were successfully extended to 100 km by using a 1358-nm-wavelength SOA integrated EADFB laser (AXEL) with an optical modulation amplitude (OMA) over 10.5 dBm.

Authors:Takahiko Shindo, NTT Device innovation center / Shigeru Kanazawa, NTT Device innovation center / Yasuhiko Nakanishi, NTT Device innovation center / Mingchen Chen, NTT Device innovation center / Masahiro Nada, NTT Device innovation center / Toshihide Yoshimatsu, NTT Device innovation center / Atsushi Kanda, NTT Device innovation center / Hirotaka Nakamura, NTT Device innovation center / Kimikazu Sano, NTT Device innovation center

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Tu1E

Wide-band Amplifiers

Presider: Chester C.T. Shu

Tu1E.1

High Gain Bi-Doped Fiber Amplifier Operating in the E-Band With a 3-dB Bandwidth of 40nm

Presenter: Yu Wang , *Optoelectronics Research Center*

We report a double-pass bismuth-doped fiber amplifier operating in the E-band providing 38dB gain with 6dB NF for -23dBm input signal at 1430nm. The amplifier 3-dB bandwidth and temperature-dependent-gain coefficient are 40nm and -0.006dB/°C, respectively.

Authors:Yu Wang, Optoelectronics Research Center / Naresh Thipparapu, Optoelectronics Research Center / David Richardson, Optoelectronics Research Center / Jayanta Sahu, Optoelectronics Research Center

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Tu1E.2

Thermal Quenching Induced Luminescence Enhancement of Bismuth/Erbium Co-Doped Fiber (BEDF) Under 830 Pumping

Presenter: QU JIAQI , *The Hong Kong Polytechnic University*

We investigated the thermal-related spectral properties for BEDF under 830 nm pumping and observed a notable (~1.6 times) luminescence enhancement in the range of 1.1-1.3 μm by thermal quenching at 500 °C.

Authors:Zhao Qiancheng, The Hong Kong Polytechnic University / Qun Hao, Beijing Institute of Technology / QU JIAQI, The Hong Kong Polytechnic University / Zongru Yang, The Hong Kong Polytechnic University / Yifan Liu, The Hong Kong Polytechnic University / Changyuan Yu, The Hong Kong Polytechnic University / Gang-ding Peng, The University of New South Wales

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Tu1E.3

4-Channel E-Band Data Transmission Over 160 km of SMF-28 Using a Bismuth-Doped Fibre Amplifier

Presenter: Aleksandr Donodin , *Aston University*

We experimentally demonstrate transmission of four 10 Gbit/s NRZ channels in the E-band over 160 km of SMF-28 using a bismuth-doped fibre amplifier with 32 dB maximum gain and 5 dB minimum NF.

Authors:Aleksandr Donodin, Aston University / Vladislav Dvoyrin, Aston University / Egor Manuylovich, Aston University / Ian Phillips, Aston University / Wladek Forysiak, Aston University / Mikhail Melkumov, Prokhorov General Physics Institute of the Russian Academy of Sciences / Valery Mashinsky, Prokhorov General Physics Institute of the Russian Academy of Sciences / Sergei K Turitsyn, Aston University

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Tu1E.4

O+E Band BDFA With Flattop 116 nm Gain Bandwidth Pumped With 250 mW at 1256 nm

Presenter: Yan Ososkov , *Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center*

We present highly efficient bismuth-doped fiber amplifier covering almost all O- and E-bands. Using 250 mW single wavelength pumping at 1256 nm and low OH bismuth-doped fiber, we managed to achieve 26dB peak gain with -3dB bandwidth of 116 nm.

Authors:Aleksandr Khegai, Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center / Yan Ososkov, Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center / Sergei Firstov, Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center / Konstantin Riumkin, Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center / Sergey Alyshev, Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center / Alexander Kharakhordin, Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center / Alexey Lobanov, Institute of Chemistry of High-Purity Substances of the Russian Academy of Sciences / Alexey Guryanov, Institute of Chemistry of High-Purity Substances of the Russian Academy of Sciences / Mikhail Melkumov, Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center

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Tu1E.5

Optimization of a Hybrid EDFA-Raman C+LBand Amplifier Through Neural-Network Models

Presenter: Francesco Da Ros , *DTU Fotonik*

Experimentally-trained neural network models are used to optimize the 12 Raman pumps of a C+L band hybrid EDFA-Raman amplifier, targeting gains with improved flatness. Gain ripples are decreased from 6.7 to 1.9 dB.

Authors:Francesco Da Ros, DTU Fotonik / Uiara de Moura, DTU Fotonik / Ruben Luis, National Institute of Information and Communications Technology / Georg Rademacher, National Institute of Information and Communications Technology / Benjamin Puttnam, National Institute of Information and Communications Technology / Margareth Rosa Brusin, Politecnico di Torino / Andrea Carena, Politecnico di Torino / Yoshinari Awaji, National Institute of Information and Communications Technology / Hideaki Furukawa, National Institute of Information and Communications Technology / Darko Zibar, DTU Fotonik

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Tu1E.6

Master-Slave Synchronization of Random Microcavity Lasers

Presenter: Hong Yang Zhu , *Univ of Electronic Science & Tech China*

We experimentally demonstrate the interaction and synchronization of random microcavity lasers. In this way, a spectral coding method is proposed, providing a potential technique to generate and share information between disordered nodes.

Authors:Hong Yang Zhu, Univ of Electronic Science & Tech China / Jin Chuan Zhang, Univ of Electronic Science & Tech China / Wei Li Zhang, Univ of Electronic Science & Tech China

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Tu1E.7

Giant Brillouin Amplification in Gas Using Hollow-Core Fiber

Invited

Presenter: Luc Thevenaz , *Ecole Polytechnique Federale de Lausanne*

Optical amplification in hollow core fibers has been achieved using stimulated Brillouin scattering directly in the gaseous medium. More than 50 dB optical gain is observed over 50 m of fiber using 200 mW of pump power.

Authors:Luc Thevenaz, Ecole Polytechnique Federale de Lausanne / Fan Yang, Ecole Polytechnique Federale de Lausanne / Flavien Gyger, Ecole Polytechnique Federale de Lausanne

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Tu1F

Panel: THz Communication for Beyond 5G Networks

Tu1G

Machine Learning in Optical Networks

Presider: Priyanth Mehta

Tu1G.1

Optimization of Power Efficient SDM Submarine Cables Using Adaptive Transponders and Machine Learning

Invited

Presenter: Jeremie Renaudier , *Nokia Bell Labs*

Abstract not available.

Authors:Jeremie Renaudier, Nokia Bell Labs / Maria Ionescu, Nokia Bell Labs / Amirhossein Ghazisaeidi, Nokia Bell Labs / Arnaud Leroy, Alcatel Submarine Network / Olivier Courtois, Alcatel Submarine Network

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Tu1G.2

Estimating Quality of Transmission in a Live Production Network Using Machine Learning

Presenter: Jasper Müller , *Adva Optical Networking SE*

We demonstrate QoT estimation in a live network utilizing neural networks trained on synthetic data spanning a large parameter space. The ML-model predicts the measured lightpath performance with <0.5dB SNR error over a wide configuration range.

Authors:Jasper Müller, Adva Optical Networking SE / Tobias Fehenberger, Adva Optical Networking SE / Sai Patri, Adva Optical Networking SE / Kaida Kaeval, Adva Optical Networking SE / Helmut Griesser, Adva Optical Networking SE / Marko Tikas, Tele2 Estonia / Jörg-Peter Elbers, Adva Optical Networking SE

Tu1G.3

Manhole Locating Technique Using Distributed Vibration Sensing and Machine Learning

Presenter: Masaki Wada , *NTT EAST*

A field trial of manhole locating technique using optical-sensing was conducted to improve the efficiency of facility inspections. Machine-learning was applied for automatic location estimation and a high precision of over 90 % was achieved.

Authors:Masaki Wada, NTT EAST / Yuu Maeda, NTT EAST / Hiroki Shimabara, NTT EAST / Takaaki Aihara, NTT EAST

Tu1G.4

In-Band OSNR Estimation From Transponder Telemetry Using Ensemble Learning

Presenter: Yingkan Chen , *Infinera Networks (Shanghai) Co., Ltd.*

Ensemble learning using transponder telemetry to minimize the maximum absolute error (MAE) of the OSNR monitoring is studied. Trained model reduces the MAE to 2.08 dB which is 10 dB smaller than commercial DSP estimates.

Authors:Yingkan Chen, Infinera Networks (Shanghai) Co., Ltd. / Bernhard Spinnler, Infinera Germany

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Tu1H

Optics for Emerging Computing Architectures

Presider: Michela Svaluto Moreolo

Tu1H.1

Towards Ultra-Efficient Nanophotonic AI Acceleration : From a Computer Architecture Perspective

Invited

Presenter: Koji Inoue , *Kyushu University*

Abstract not available.

Authors:Koji Inoue, Kyushu University / Satoshi Kawakami, Kyushu University

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Tu1H.2

Spatial Photonic Reservoir Computing Based on Non-Linear Phase-to-Amplitude Conversion in Micro-Ring Resonators

Presenter: Charis Mesaritakis , *University of the Aegean*

We present a photonic reservoir computing, relying on a non-linear phase-to-amplitude mapping process, able to classify in real-time multi-Gbaud time traces subject to transmission effects. This approach delivers an all-optical, low-power neuromorphic dispersion compensator.

Authors:Charis Mesaritakis, University of the Aegean / Kostas Sozos, University of West Attica / Dimitris Dermanis, University of the Aegean / Adonis Bogris, University of West Attica

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Tu1H.4

A Dynamic Time-Evolution Control Method to Improve the Performance of Optoelectronic Coherent Ising Machine

Presenter: Zhenhua Li , *Sun Yat-Sen University*

A simple dynamic time-evolution control method is proposed and experimentally demonstrated in an opto-electronic-oscillator based coherent Ising machine. The experimental results show significant performance improvement can be realized using this method at different parameter settings.

Authors:Zhenhua Li, Sun Yat-Sen University / Jie Liu, Sun Yat-Sen University / Siyuan Yu, Sun Yat-Sen University

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Tu1I

Security and Quantum Networking

Presider: Christine Tremblay

Tu1I.1

Autonomous Security Management in Optical Networks

Invited

Presenter: Marija Furdek , *Chalmers Tekniska Hogskola*

The paper describes the Optical Security Manager module and focuses on the role of Machine Learning (ML) techniques. Issues related to accuracy, run-time complexity and interpretability of ML outputs are described and coping strategies outlined.

Authors:Carlos Natalino, Chalmers Tekniska Hogskola / Andrea Di Giglio, Telecom Italia / Marco Schiano, Telecom Italia / Marija Furdek, Chalmers Tekniska Hogskola

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Tu1I.2

Experimental Demonstration of Programmable 100 Gb/s SDN-Enabled Encryptors/Decryptors for QKD Networks

Presenter: Ekin Arabul , *University of Bristol*

We successfully demonstrated on-demand and programmable encryption/decryption using SDN-enabled FPGA-based technology over a QKD network. Data rate over 90 Gb/s with maximum data encryption of 11.25 GB/s for different encryption schemes were achieved

Authors:Ekin Arabul, University of Bristol / Rodrigo Tessinari, University of Bristol / obada alia, University of Bristol / Emilio Hugues-Salas, University of Bristol / George Kanellos, University of Bristol / Reza Nejabati, University of Bristol / Dimitra Simeonidou, University of Bristol

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Tu1I.3

Gb/s Secure Key Distribution Based on Synchronization of Polarization States

Presenter: Liuming Zhang , *Shanghai Jiao Tong University*

We propose and demonstrate a high-speed physical-layer key distribution in fiber networks using synchronization of polarization states. An error-free and true random key generation rate of 2 Gb/s is achieved over 20 km single-mode fiber.

Authors:Liuming Zhang, Shanghai Jiao Tong University / Weisheng Hu, Shanghai Jiao Tong University / Xuelin Yang, Shanghai Jiao Tong University

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Tu1I.4

AI-Enabled Large-Scale Entanglement Distribution Quantum Networks

Presenter: Rui Wang , *University of Bristol*

We propose an entanglement distribution switching architecture to support large-scale dynamic quantum networking. Deep neural networks are further developed for predicting the performance of a dynamic entanglement distribution network utilizing the proposed architecture.

Authors:Rui Wang, University of Bristol / Siddarth Koduru Joshi, University of Bristol / George Kanellos, University of Bristol / Djeylan Aktas, University of Bristol / John Rarity, University of Bristol / Reza Nejabati, University of Bristol / Dimitra Simeonidou, University of Bristol

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Tu1I.5

End-to-End Network Slice Stitching Using Blockchain-Based Peer-to-Peer Network Slice Managers and Transport SDN Controllers

Presenter: Pol Alemany , *CTTC*

This paper presents and experimentally validates a Blockchain-based architecture to manage End-to-End Network Slice Deployment by stitching Network Slice Subnets in edge/cloud computing domains connected through packet/optical transport networks domains managed by different operators.

Authors:Pol Alemany, CTTC / Ricard Vilalta, CTTC / Raul Muñoz, CTTC / Ramon Casellas, CTTC / Ricardo Martínez, CTTC

Tu1J

Future Directions in Access and Local Area Networks

Presider: Liang Du

Tu1J.1

Lessons Learn From a Tactile Internet Testbed: an Access Network Perspective

Invited

Presenter: Hwan Seok Chung , *Electronics and Telecom Research Inst*

We review TDM-PON based optical access for 5G and tactile internet applications, and introduce recent feasibility studies based on high-capacity and low latency TDM-PON. Lessons learned from the tactile internet testbed are also discussed.

Authors:Hwan Seok Chung, Electronics and Telecom Research Inst / Han Hyub Lee, Electronics and Telecom Research Inst / KwangOk Kim, Electronics and Telecom Research Inst / Kyung Hwan Doo, Electronics and Telecom Research Inst

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Tu1J.2

Spatial Diversity Performance of DMT, PAM4 Gigabits per Second Transmission Using POF as Luminaires

Presenter: Carina Ribeiro Barbio Corrêa , *Eindhoven University of Technology*

A spatial diversity scheme using 1mm core size plastic optical fibre as luminaires with 1.2m free space is experimentally evaluated. Discrete multitone and pulse amplitude modulation on a red wavelength demonstrate throughputs of 3.3Gbps.

Authors:Carina Ribeiro Barbio Corrêa, Eindhoven University of Technology / Eduward Tangdiongga, Eindhoven University of Technology / A.M.J. Koonen, Eindhoven University of Technology

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Tu1J.3

Research on Precoding Enabled Geometrically Shaped 64-QAM Signal in Short-Reach DMT Transmission Systems

Presenter: Jie Ma , *Hunan University*

In short-reach DMT transmission systems, we proposed geometrically-shaped (GS) 64-QAM signal, which can achieve significant shaping gain while ensuring lower demodulation complexity. The results show that precoding enabled GS-64QAM DMT outperforms uniform 64-QAM DMT.

Authors:Jie Ma, Hunan University / J He, Hunan University / Zhihua Zhou, Hunan University / Jing He, Hunan University

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Tu1J.4

Experimental Demonstration of Adaptive Bit and Power Loading Algorithm for OFDM-NOMA PON

Presenter: Geyang Wang , *South China University of Technology*

We propose the first adaptive bit-and-power loading scheme for OFDM-NOMA-PON and demonstrate in a 54-Gbit/s 20-km PON that this scheme outperforms conventional OFDM-NOMA and DFT-S-OFDM-NOMA when ONUs have different transmission distances or different power loss

Authors:Geyang Wang, South China University of Technology / Zhaoquan Fan, South China University of Technology / Jian Zhao, South China University of Technology

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Tu1K

Photonic Integrated Subsystems

Presider: Hao Hu

Tu1K.1

Programmable Silicon Photonic Circuits

Tutorial

Presenter: Wim Bogaerts , *Ghent University - IMEC*

We present the new field of programmable photonic circuits. We introduce the evolution from specialized photonic circuits to general-purpose photonic processors, and describe the layers in the technology stack and their challenges.

Authors:Wim Bogaerts, Ghent University - IMEC

Tu1K.2

Lossless Silicon Photonic ROADM Based on a Si_3N_4 Platform and a Monolithically Integrated Erbium Doped Amplifier

Presenter: Christos Vagionas , *Aristotle University of Thessaloniki*

The first demonstration of a lossless four-port silicon photonic ROADM-node based on a monolithic-integrated spiral $Al_2O_3:Er^{3+}$ Erbium Doped Waveguide Amplifier and MZI-interleaver layout on a Si_3N_4 platform is presented, routing a 4×50Gb/s WDM data-traffic capacity

Authors:Christos Vagionas, Aristotle University of Thessaloniki / Apostolos Tsakyridis, Aristotle University of Thessaloniki / Themistoklis Chrysostomidis, Aristotle University of Thessaloniki / Ioannis Roumpos, Aristotle University of Thessaloniki / Konstantinos Fotiadis, Aristotle University of Thessaloniki / Athanasios Manolis, Aristotle University of Thessaloniki / Jinfeng Mu, MESA+ Institute for Nanotechnology, University of Twente / Meindert Dijkstra, MESA+ Institute for Nanotechnology, University of Twente / Sonia Garcia-Blanco, MESA+ Institute for Nanotechnology, University of Twente / Ruud Oldenbeuving, LIONIX International B.V. / Paul Van Dijk, LIONIX International B.V. / Chris Roeloffzen, LIONIX International B.V. / Konstantinos Vyrsokinos, Aristotle University of Thessaloniki / Nikos Pleros, Aristotle University of Thessaloniki / Theonitsa Alexoudi, Aristotle University of Thessaloniki

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Tu1K.3

20 Gb/s WDM Optical RAM Row Architecture Based on Four Monolithic Integrated InP Memory Cells

Presenter: Theonitsa Alexoudi , *Center for Interdisciplinary Research and Innovation, Aristoteleio Panepistimio Thessalonikis*

A complete 4-bit WDM-enabled all-optical RAM Row architecture with 20 Gb/s memory-bus throughput is experimentally presented for the first time, using four 5Gb/s monolithic InP Flip-Flops and a multi-wavelength Random Access and Column Selector peripheral circuit.

Authors:Theonitsa Alexoudi, Center for Interdisciplinary Research and Innovation, Aristoteleio Panepistimio Thessalonikis / Konstantinos Fotiadis, Center for Interdisciplinary Research and Innovation, Aristoteleio Panepistimio Thessalonikis / George Mourgias-Alexandris, Center for Interdisciplinary Research and Innovation, Aristoteleio Panepistimio Thessalonikis / Nikos Pleros, Center for Interdisciplinary Research and Innovation, Aristoteleio Panepistimio Thessalonikis / Christos Vagionas, Center for Interdisciplinary Research and Innovation, Aristoteleio Panepistimio Thessalonikis

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Tu1K.4

Wideband Laser Linewidth Reduction Using a Hybrid Integrated Phase Noise Filter

Invited

Presenter: Firooz Aflatouni , *University of Pennsylvania*

The first nanophotonic phase noise filter is demonstrated that reduces laser linewidth from 2.55 MHz to 4 kHz and from 200 kHz to 320 Hz. The electronic and photonic chips occupy 3 mm2 of area.

Authors:Firooz Aflatouni, University of Pennsylvania / Mohamad Hossein Idjadi, University of Pennsylvania

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Tu1L

Fiber-optical Sensing Systems

Presider: Luca Palmieri

Tu1L.1

Distributed Optical Fiber Sensor for Oil and Gas Industry and Agricultural Applications

Tutorial

Presenter: Boon Ooi , *King Abdullah Univ of Sci & Technology*

In this tutorial, we will give a general overview on recent advances of DAS and DTS technologies, and focus our discussion on their present and future applications to oil-gas and agricultural industrials.

Authors:Boon Ooi, King Abdullah Univ of Sci & Technology

Tu1L.2

Distributed Acoustic Sensing for Seismic Monitoring

Invited

Presenter: Miguel Gonzalez-Herraez , *Universidad de Alcala*

Optical fiber networks can be transformed into powerful seismic sensing arrays through Distributed Acoustic Sensing (DAS). We review here the principles of DAS and the opportunities it offers in seismic monitoring, particularly in the sea-bottom.

Authors:Miguel Gonzalez-Herraez, Universidad de Alcala / Maria R. Fernandez-Ruiz, Universidad de Alcala / Regina Magalhaes, Universidad de Alcala / Luis Costa, Universidad de Alcala / Hugo Martins, Consejo Superior de Investigaciones Científicas (CSIC) / Carlos Becerril, Universidad de Alcala / Sonia Martin-Lopez, Universidad de Alcala / Ethan Williams, California Institute of Technology (Caltech) / Zhongwen Zhan, California Institute of Technology (Caltech) / Roel Vantilho, Marlinks

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5:30 - 6:30 Pacific Time (US & Canada) (UTC - 07:00)

SF1

Exhibit Hall Event - Industry Program: OpenROADM -- Now a Reality

5:30 - 7:30 Pacific Time (US & Canada) (UTC - 07:00)

Tu2A

Symposia: On the Edge: MEC- based Network Architectures in Support of Enterprise Cloud (Part 2)

Presider: Reza Nejabati

Tu2A.1

Using the Capacity and Low Latency of Mobile Edge Clouds for Community Applications

Invited

Presenter: Daniel Kilper , *Trinity College Dublin*

A community edge cloud is developed to use high capacity, low latency mobile edge clouds to realize community-wide, shared virtual desktop computing. Initial latency experiments show 10 ms latency tolerance for video streaming applications.

Authors:Daniel Kilper, Trinity College Dublin / Hongying Dong, University of Virginia / Aaron Knife, University of Virginia / Jiakai Yu, University of Arizona / Qi Liu, University of Virginia / Kevin Kim, Silicon Harlem / Bruce Lincoln, Silicon Harlem / Clayton Banks, Silicon Harlem / Sheila Foster, Georgetown University / Olivier Sylvain, Fordham University / Rider Foley, University of Virginia / Ronald Williams, University of Virginia

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Tu2A.3

Cloud-Native Abstractions for Network Programmability

Invited

Presenter: Landon Cox , *Microsoft*

Abstract not available.

Authors:Landon Cox, Microsoft

Tu2A.4

Cloud Native Development for Extending Hybrid Cloud Applications to the Edge

Invited

Presenter: Mo Haghighi , *IBM*

This talk will showcase the power of cloud native development to “build once and deploy anywhere”. Developers can take advantage of Cloud Native development to decouple their applications from the infrastructure by adopting microservices architecture and containerisation.

Authors:Mo Haghighi, IBM

(Withdrawn) AI Beyond ML/DL From Edge to Cloud

Invited

Presenter: Hugo Latapie , *Cisco*

Abstract not available.

Authors:Hugo Latapie, Cisco

7:00 - 8:00 Pacific Time (US & Canada) (UTC - 07:00)

SF2

Exhibit Hall Event - Industry Program: DARPA Project Update

SF3

Exhibit Hall Event - Industry Program: Standards Update on 5G Transport, Higher Speed PON, Latest OTN Technologies and Interoperable Optical Coherent Interfaces

SF4

Exhibit Hall Event - Industry Program: The 5th Generation Fixed Networks (F5G): New Use Cases and Technologies

SpE5

Special Event - Tech Group: Nonlinear Signal Processing Coming of Age: From Niche Lab Demonstrations to Network Components

8:00 - 11:00 Pacific Time (US & Canada) (UTC - 07:00)

Tu3A

Plenary Session and Awards Ceremony

Presider: Chongjin Xie

Tu3A.1

Hammers and Nails: How Technologies and Applications Drive the Evolution of Networking in Alibaba

Plenary

Presenter: Yiqun Cai , *Alibaba Group*

Abstract not available.

Authors:Yiqun Cai, Alibaba Group

Tu3A.2

Symbiotic Perspective of Photonics and Artificial Intelligence

Plenary

Presenter: Young-Kai Chen , *DARPA*

Abstract not available.

Authors:Young-Kai Chen, DARPA

Tu3A.3

Industrial Revolution 4.0 — Gone Country

Plenary

Presenter: Nancy Shemwell , *Trilogy Networks*

Abstract not available.

Authors:Nancy Shemwell, Trilogy Networks

10:00 - 10:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC9

Exhibit Hall Event - Technology Showcase: Scalable Implementation of Next Generation Security Technologies for Enterprise and Access Networks

10:00 - 11:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

10:30 - 11:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC10
Exhibit Hall Event - Technology Showcase: XR Optics: Applications and Network Benefits

10:30 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

MW1
Exhibit Hall Event - Market Watch: State of the Industry

SpE2
Exhibit Hall Event - OFC Career Zone Part Two: Career (Re) Start: Elevator Pitch, Resume Tips and Interview Best Practices

11:00 - 11:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE11
Exhibit Hall Event - OSA Booth, Tech Talk: 50G-PON: The Latest ITU PON System

11:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

Special Event - Demo Zone Demonstrations in Action

SF5
Exhibit Hall Event - Industry Program: Electrical Data Rates Keep Pushing Forward; An OIF Update

11:00 - 13:05 Pacific Time (US & Canada) (UTC - 07:00)

Tu4A

Symposia: Emerging Photonic Technologies and Architectures for Femtojoule per Bit Optical Networks (Part 1)

Presider: Daniel Blumenthal

Tu4A.1

Towards Power-Efficient Data-Center Networks

Invited

Presenter: Kai Shi , *Microsoft Research*

In this talk, we will present our journey in improving the power efficiency of data-center networks, through a combination of nanosecond optical switching and novel transceiver architectures.

Authors:Kai Shi, Microsoft Research

Tu4A.2

Intra-Chip Communications and Power Requirements Tutorial: What it Takes for fJ/bit on a Photonic/Electronic Chip

Invited

Presenter: Erman Timurdogan , *Analog Photonics*

Abstract not available.

Authors:Erman Timurdogan, Analog Photonics

Tu4A.3

Plasmonic Data Center Interconnects (DCIs)

Invited

Presenter: Juerg Leuthold , *ETH Zurich*

Data centers require optical interconnect solutions that are highly scalable with respect to the channel count, the bit rates and the power consumption. Plasmonics offers smallest footprints, operates up to highest speed, requires little driver circuitry and thus meets many of the DCI requirements.

Authors:Juerg Leuthold, ETH Zurich / Benedikt Baeuerle, Polariton Technologies Inc. / Wolfgang Heni, Polariton Technologies Inc. / Claudia Hoessbacher, Polariton Technologies Inc. / Loïc Chérix, ETH Zurich / David Moor, ETH Zurich / Marco Eppenberger, ETH Zurich / Yuriy Fedoryshyn, ETH Zurich / Ueli Koch, ETH Zurich / Jasmin Smajic, ETH Zurich

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Tu4A.4
Will it be Coherent or not Coherent
Invited

Presenter: Peter Winzer , *Nubis Communications*

Abstract not available.

Authors:Peter Winzer, Nubis Communications

11:45 - 12:15 Pacific Time (US & Canada) (UTC - 07:00)

DCSK
Exhibit Hall Event - Data Center Summit Keynote: Gaya Nagarajan

12:00 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE12
Exhibit Hall Event - OSA Booth, Tech Talk: Lessons Learned in Data Transmission and Processing in Optical Communication Systems

12:00 - 13:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE6
Special Event - Educational Worldwide Lab Tour: Part 1

12:15 - 13:45 Pacific Time (US & Canada) (UTC - 07:00)

DCS1
Exhibit Hall Event - Data Center Summit: What is Next for Inter Data Center Interconnects (DCIs)?

12:30 - 13:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE19
Special Event - OFC Media/Analyst Panel: Data Center Optics are Heading Toward Co-packaged Optics: Why, How and When?

14:00 - 14:15 Pacific Time (US & Canada) (UTC - 07:00)

SF6

Exhibit Hall Event - Industry Program: Tribute to Mitchell Fields

14:00 - 16:00 Pacific Time (US & Canada) (UTC - 07:00)

Tu5B

Process Tolerant Devices and Design Methods

Presider: Kenya Suzuki

Tu5B.1

Process Variation-Aware Photonic Design

Invited

Presenter: Duane Boning , *Massachusetts Institute of Technology*

We present methods for variation-aware compact models, adjoint-based particle defect analysis, and variation extraction for photonic components. These methods can expedite ensemble simulations and enable design-for-manufacturability to increase yield in photonic integrated circuit design.

Authors:Duane Boning, Massachusetts Institute of Technology / Sally El-Henawy, Massachusetts Institute of Technology / Zhengxing Zhang, Massachusetts Institute of Technology

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Tu5B.2

Fabrication-Tolerant Nitride Lattice Filter for CWDM

Presenter: Jonathan Yiho Lee , *Cisco Systems Inc*

We experimentally demonstrate an all-nitride passive 2-channel cascaded lattice filter with <1.7nm (6σ) wavelength variation across four CMOS wafers by implementing fabrication insensitive MZI design.

Authors:Jonathan Yiho Lee, Cisco Systems Inc / Tao Ling, Cisco Systems Inc / Ravi Tummidi, Cisco Systems Inc / Mark Webster, Cisco Systems Inc / Prakash Gothoskar, Cisco Systems Inc

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Tu5B.3

Calibration-Free Mach-Zehnder Silicon-Photonic Switch

Presenter: lijia song , *Zhejiang University*

We propose calibration-free Mach-Zehnder silicon-photonic-switch networks based on new 2×2 Mach-Zehnder switches with ultralow random phase errors (~0.02π rad). The demonstrated 4×4 Benes switch has <−20 dB crosstalk in the C-band.

Authors:lijia song, Zhejiang University / Huan Li, Zhejiang University / Daoxin Dai, Zhejiang University

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Tu5B.4

Demonstration and Fabrication Tolerance Study of a Low-Loss,Ultra-Broadband Rapid Adiabatic 3-dB Coupler in a Next-Generation 45 nm Monolithic Electronic-Photonic Platform

Presenter: Josep Fargas Cabanillas , *Ayar Labs Inc*

We demonstrate a rapid adiabatic coupler (RAC) with 50±1.08% power splitting ratio over 100 nm and insertion loss<0.2 dB at 1290 nm. We measure the device over seven reticles and show low variations in splitting ratio and insertion loss across the wafer.

Authors:Josep Fargas Cabanillas, Ayar Labs Inc / Derek Kita, Ayar Labs Inc / Anatol Khilo, Ayar Labs Inc / Forrest Sedgwick, Ayar Labs Inc / John Fini, Ayar Labs Inc / Milos Popovic, Boston University / Mark Wade, Ayar Labs Inc

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Tu5B.5

Thermo-Optic Mach–Zehnder Interferometer Integrated With Si PN Diode Switch for Bipolar Optical Phase Control

Presenter: Hanzhi Tang , *University of Tokyo*

We demonstrated the bipolar phase control in Mach–Zehnder interferometer by serial connection of TiN heaters and PN diodes. We achieved ±2π phase shift with single electrical signal, and pulse amplitude modulation for time-multiplexed control.

Authors:Hanzhi Tang, University of Tokyo / Shuhei Ohno, University of Tokyo / Yuto Miyatake, University of Tokyo / Kasidit Toprasertpong, University of Tokyo / Shinichi Takagi, University of Tokyo / Mitsuru Takenaka, University of Tokyo

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Tu5B.6

(Withdrawn) Prototype of DSP-Free IM/DD MDM Transceiver Based on Multiple-Ring-Core FMF for Datacenter Interconnection

Invited

Presenter: Haifeng Li , *TE SubCom*

Abstract not available.

Authors:Haifeng Li, TE SubCom

Tu5C

VCSEL Communication Links

Presider: Michael Tan

Tu5C.1

1060nm Single-Mode Metal Aperture VCSEL Array With Transverse Resonance for 5km Single-Mode Fiber Transmission

Presenter: Hameeda Ragab , *Tokyo Institute of Technology*

We demonstrate 5km-long single-mode fiber transmission using 1060nm single-mode intracavity-metal-aperture VCSEL array with over 46Gbps modulations. The metal-aperture causes transverse-resonance, resulting in single-mode operation and bandwidth enhancement. The effective bandwidth is improved thanks to the negative dispersion.

Authors:Hameeda Ragab, Tokyo Institute of Technology / Ahmed Hassan, Tokyo Institute of Technology / Xiaodong Gu, Tokyo Institute of Technology / Satoshi Shinada, National Institute of Information and Communications Technology / Moustafa Ahmed, King Abdulaziz University / Fumio Koyama, Tokyo Institute of Technology

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Tu5C.2

Advanced Single-Mode 850 nm VCSEL for Record NRZ and PAM4 Data Rates on SMF-28 Fiber up to 1 km

Presenter: Dufei Wu , *UIUC*

Temperature-stable single-mode 850 nm VCSELs with integrated mode-selective filters are developed and demonstrated record NRZ 38 Gb/s (25 °C), NRZ 32 Gb/s (70 °C) and PAM4 32 GBaud (25 °C) on 1 km standard single-mode fiber (SMF-28).

Authors:Junyi Qiu, UIUC / Dufei Wu, UIUC / Hsiao-Lun Wang, UIUC / Milton Feng, UIUC / Xin Yu, Foxconn Interconnect Technology

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Tu5C.3

850-nm Dual-Mode VCSEL Carried 53-Gbps NRZ-OOK Transmission in 100-m Graded-Index Single-Mode Fiber

Presenter: SHAO-YUNG LEE , *National Taiwan University*

We demonstrated transmission of 850-nm dual-mode VCSEL carried NRZ-OOK data at 53 Gbit/s over 100 m graded-index single-mode fiber through heterogeneous mode-field mismatched coupling from lensed MMF with 40% efficiency or 4dB loss.

Authors:SHAO-YUNG LEE, National Taiwan University / Xin Chen, Corning Inc. / Wei-Chi Lo, National Taiwan University / Kangmei Li, Corning Inc. / Chia-Hsuan Wang, Corning Inc. / Cheng Tsai, National Taiwan University / Chih-Hsien Cheng, National Taiwan University / Chao-Hsin Wu, National Taiwan University / Hao-Chung Kuo, National Chiao Tung University / Ming-Jun Li, Corning Inc. / Gong-Ru Lin, National Taiwan University

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Tu5C.4

Cryogenic Oxide-VCSELs With Bandwidth Over 50 GHz at 82 K for Next-Gen High-Speed Computing

Presenter: Wenning Fu , *University of Illinois Urbana-Champaign*

A Cryo-VCSEL with f_{-3db} > 50 GHz has been demonstrated at 82 K. Preliminary 44-Gb/s NRZ and 51.5625-Gb/s PAM-4 transmission for an optical data link from cryogenic environment to room temperature with a packaged 50-GHz oxide-VCSEL at 77 K are reported.

Authors:Wenning Fu, University of Illinois Urbana-Champaign / Haonan Wu, University of Illinois Urbana-Champaign / Dufei Wu, University of Illinois Urbana-Champaign / Milton Feng, University of Illinois Urbana-Champaign / Dennis Deppe, sdPhotonics LLC

Tu5C.5

High-Power, Low-Noise, and High-Speed 850 nm VCSEL Arrays With for Optical Wireless Transmission

Presenter: Zuhaib Khan , *National Central University*

850nm VCSEL arrays (7x7) using Zn-diffusion/Oxide-relief apertures have been demonstrated. It exhibits high CW power (190 mW), dampening E-O frequency response, and wide 3-dB E-O bandwidths (13 GHz). 25Gbit/sec error-free transmission has been demonstrated.

Authors:Zuhaib Khan, National Central University / Lukasz CHORCHOS, VI Systems GmbH / Yong-Hao Chang, National Central University / Nikolay Ledenstov Jr., VI Systems GmbH / Yen-Yu Huang, National Central University / Yaung-Cheng Zhao, National Central University / Nikolay Ledentsov, VI Systems GmbH / Jin-Wei Shi, National Central University

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Tu5D

Short-reach Systems

Presider: Xi Chen

Tu5D.1

Distance-Agnostic Auto-Encoders for Short Reach Fiber Communications

Invited

Presenter: Boris Karanov , *Eindhoven University of Technology*

Strategies for optimization of 100 Gb/s neural network-based transceivers are investigated for ensuring tolerance to transmission link variations. Exploiting the robustness/error rate trade-off, operation below HD-FEC is achieved for a wide range of distances without transceiver reconfiguration.

Authors:Boris Karanov, Eindhoven University of Technology / Alex Alvarado, Eindhoven University of Technology / Laurent Schmalen, Karlsruhe Institute of Technology

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Tu5D.2

A High-Skew-Tolerant and Hardware-Efficient Adaptive Equalizer for Short-Reach Coherent Transmission

Presenter: Tingting Zhang , *Huawei Technologies Co. Ltd.*

A hardware-efficient adaptive equalization with high robustness to timing skew is proposed for digital coherent short-reach transmission. Complexity reduction of 57% and 19% is experimentally demonstrated, compared with conventional MIMO and other simplified algorithms.

Authors:Tingting Zhang, Huawei Technologies Co. Ltd. / Qian Xiang, Huawei Technologies Co. Ltd. / Sen Zhang, Huawei Technologies Co. Ltd. / Lei Liu, Huawei Technologies Co. Ltd. / Tianjian Zuo, Huawei Technologies Co. Ltd.

Tu5D.3

Long Short-Term Memory Neural Network for Mitigating Transmission Impairments of 160 Gbit/s PAM4 Microring Modulation

Presenter: CHING-WEI PENG , *National Chiao Tung University*

We propose and design a Long-Short-Term-Memory (LSTM) algorithm to mitigate transmission impairments of 4-level-pulse-amplitude-modulation (PAM4) produced by silicon-microring-modulator (Si-MRM). 160-Gbit/s PAM4 over 1-km single-mode-fiber (SMF) is achieved satisfying the pre-forward-error-correction (FEC) requirement.

Authors:CHING-WEI PENG, National Chiao Tung University / David Chan, Chinese University of Hong Kong / Yeyu Tong, Chinese University of Hong Kong / Chi-Wai Chow, National Chiao Tung University / Yang Liu, Philips Electronics Ltd / Chien-Hung Yeh, Feng Chia University / Hon Tsang, Chinese University of Hong Kong

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Tu5D.4

Hybrid Digital-Analog Radio-Over-Fiber (DA-RoF) Modulation and Demodulation Achieving a SNR Gain Over Analog RoF of >10 dB at Halved Spectral Efficiency

Presenter: Xiang Liu , *FutureWei Technologies Inc*

We propose and experimentally demonstrate a hybrid digital-analog radio-over-fiber technique based on cascaded digital PCS-121-QAM modulation and analog pulse code modulation for each radio waveform sample, achieving 12.8 dB SNR gain over A-RoF and 1.38% EVM.

Authors:Xiang Liu, FutureWei Technologies Inc

Tu5D.5

Entanglement Assisted Communication vs. Classical Optical Communication

Presenter: Ivan Djordjevic , *University of Arizona*

We demonstrate that under imperfect preshared entanglement-distribution, entanglement-assisted (EA) communication can be inferior compared to classical communication. When both signal and idler channels are used for classical transmission then classical capacity is always higher than EA-capacity.

Authors:Ivan Djordjevic, University of Arizona

Tu5E
Positioning, Localization and Tracking Systems

Presider: Peng-Chun Peng

Tu5E.1

Passive Positioning Using Visible Light Systems

Invited

Presenter: Steve Hranilovic , *McMaster University*

Passive indoor visible light localization detects changes in illumination patterns in a room to infer the position of a user. We present analytical bounds on positioning error of an object in an indoor scenario and use deep learning to estimate positioning in realistic scenarios.

Authors:Khaqan Majeed, McMaster University / Steve Hranilovic, McMaster University

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Tu5E.3

Using DIALux and Regression-Based Machine Learning Algorithm for Designing Indoor Visible Light Positioning (VLP) and Reducing Training Data

Collection

Presenter: Shao-Hua Song , *National Chiao Tung University*

We propose and demonstrate using DIALux software with regression-machine-learning for designing visible-light-positioning (VLP) systems. Besides, the proposed scheme can also reduce the burden of training data collection in VLP systems.

Authors:Shao-Hua Song, National Chiao Tung University / Dong-Chang Lin, National Chiao Tung University / Yun-Han chang, National Chiao Tung University / Yun-Shen Lin, National Chiao Tung University / Chi-Wai Chow, National Chiao Tung University / Yang Liu, Philips Electronics Ltd / Chien-Hung Yeh, Feng Chia University / Kun-Hsien Lin, Industrial Technology Research Institute / Yi-Chang Wang, Industrial Technology Research Institute / Yi-Yuan Chen, Industrial Technology Research Institute

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Tu5E.4

Photon-Counting LIDAR Based on a Fractal SNSPD

Presenter: Nan Hu , *Tianjin University*

We report on a photon-counting LIDAR system based on a polarization-insensitive fractal SNSPD with high detection efficiency and high timing resolution, and showcase depth imaging of an object at 1560 nm with millimeter depth resolution.

Authors:Nan Hu, Tianjin University / Yifan Feng, Tianjin University / Liang Xu, Tianjin University / Yun Meng, Tianjin University / Kai Zou, Tianjin University / Samuel Gyger, Royal Institute of Technology / Stephan Steinhauer, Royal Institute of Technology / Val Zwiller, Royal Institute of Technology / Xiaolong Hu, Tianjin University

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Tu5E.5

Auto-Aligned OWC Receiver for Indoor Mobile Users Using Gradient Descent Algorithm

Presenter: Ngoc Quan Pham , *Eindhoven University of Technology*

We developed a new auto-aligned optical wireless receiver for indoor mobile users using a dual-axis actuator, a motion sensor, and a feedback control. Experiments demonstrate seamless transmission at normal walking speeds with <400ms alignment time.

Authors:Ngoc Quan Pham, Eindhoven University of Technology / Ketemaw Mekonnen, Eindhoven University of Technology / Eduward Tangdiongga, Eindhoven University of Technology / Ali Mefleh, KPN / Ton Koonen, Eindhoven University of Technology

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Tu5E.6

Real-Time Demonstration of 5G MMW Beamforming and Tracking Using Integrated Visible Light Positioning System

Presenter: CHIN-WEI HSU , *Georgia Institute of Technology*

A real-time millimeter wave beamforming and tracking technique is developed and experimentally demonstrated to achieve fast connection and agile tracking within 2 ms to different directions through an integrated machine-learning based visible light positioning system.

Authors:CHIN-WEI HSU, Georgia Institute of Technology / Shang-Jen Su, Georgia Institute of Technology / You-Wei Chen, Georgia Institute of Technology / Qi Zhou, Georgia Institute of Technology / Yahya Alfadhli, Georgia Institute of Technology / Gee-Kung Chang, Georgia Institute of Technology

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Tu5E.7

Data-Efficient Artificial Neural Networks With Gaussian Process Regression for 3D Visible Light Positioning

Presenter: Weikang Zeng , *South China Normal University*

A data-efficient artificial neural network based 3D VLP system using Gaussian process regression is proposed and experimentally demonstrated. Training data from the real environment can be reduced by >50% with negligible loss in positioning accuracy.

Authors:Weikang Zeng, South China Normal University / Huayang Chen, South China Normal University / Jiajia Chen, South China Normal University / Xuezhi Hong, South China Normal University

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Tu5E.2

LiDAR Integrated High-Capacity Indoor OWC System With User Localization Capability

Presenter: Zhi Li , *Tsinghua University*

We demonstrated an indoor beam-steered optical wireless communication system with a downlink transmission of 17 Gbps at 3-meter distance and it features calibration-free user terminal localization enabled by a LiDAR of millimeter level ranging accuracy.

Authors:Zhi Li, Tsinghua University / Zihan Zang, Tsinghua University / Mutong Li, Tsinghua University / Hongyan Fu, Tsinghua University

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Tu5F

RF Photonics

Presider: Tiziana Bond

Tu5F.1

Integrated Microwave Photonic Filters

Invited

Presenter: Yang Liu , *University of Sydney*

Microwave signal filtering is a fundamental and central functionality in radio frequency systems. We review the principles, architectures, and superior performance of emerging integrated microwave photonic filters enabled by on-chip linear and nonlinear photonic devices.

Authors:Yang Liu, University of Sydney / Amol Choudhary, Ultra Fast Optical Communications and High-performance Integrated Photonics / David Marpaung, University of Twente / Benjamin Eggleton, University of Sydney

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Tu5F.2

Photonics-Based Tunable 1-50 GHz RF Transmitter on Chip

Presenter: Antonella Bogoni , *CNIT*

The paper presents an innovative tunable software-defined RF transmitter based on integrated photonics, able to work in 1-50GHz with very fast tuning. The system has been characterized and verified in a communication scenario

Authors:Antonella Bogoni, CNIT / Fabio Falconi, Sant'Anna School of Advanced Studies / Claudio Porzi, Sant'Anna School of Advanced Studies / Muhammad Malik, Sant'Anna School of Advanced Studies / Filippo Scotti, CNIT / Antonio Malacarne, CNIT / Paolo Ghelfi, CNIT

Tu5F.3

High Performance Microwave Photonic Downconversion in a Commercial InP Platform

Presenter: Christian Bottenfield , *Georgia Institute of Technology*

We demonstrate InP's photonic integration promise for high performance microwave photonic applications through the realization and characterization of a monolithically integrated photonic downconverter achieving 104 dB●$Hz^{2/3}$ SFDR and near unity gain of -0.8 dB.

Authors:Christian Bottenfield, Georgia Institute of Technology / Michael Hoff, Georgia Institute of Technology / Varghese Thomas, Georgia Institute of Technology / Ardy Winoto, Infinera Inc. / Yuchun Zhou, Infinera Inc. / Ashish Bhardwaj, Infinera Inc. / Gloria Hoefler, Infinera Inc. / Richard DeSalvo, L3Harris Technologies / Stephen Ralph, Georgia Institute of Technology

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Tu5F.4

Performance of Dual Frequency Comb Channelizers for RF Signal Processing

Presenter: Callum Deakin , *University College London*

We analyse the performance limits of dual frequency comb based photonic signal processors. We show that the relative phase noise between the two combs is critical to defining the signal-to-noise-ratio of such systems.

Authors:Callum Deakin, University College London / Zhixin Liu, University College London

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Tu5F.5

A Power-Efficient 20–35 GHz MZM Driver With Programmable Linearizer in 28nm CMOS

Presenter: Yu-Lun Luo , *TAMU*

A power-efficient CMOS Mach-Zehnder modulator (MZM) driver operating over wide 20-35GHz frequency range with a programmable linearizer is reported. The proposed linearizer can compensate for AM-AM compression, extending output power 1-dB compression point by 3dB.

Authors:Yu-Lun Luo, TAMU / Ali Ershadi, TAMU / Ramy Rady, TAMU / Kamran Entesari, TAMU / Samuel Palermo, TAMU

Tu5F.6

Optical Up/Down-Conversion of OFDM WirelessSignals Based on Ultracompact SiliconOptomechanical Cavities

Presenter: Laura Mercade , *Universitat Politecnica de Valencia*

We demonstrate all-optical up- and down-conversion of IEEE 802.16 WiMAXOFDM signals using an ultracompact silicon optomechanical crystal cavity operated in thephonon lasing regime at 4 GHz.

Authors:Laura Mercade, Universitat Politecnica de Valencia / Maria Morant, Universitat Politecnica de Valencia / Amadeu Griol, Universitat Politecnica de Valencia / Roberto Llorente, Universitat Politecnica de Valencia / Alejandro Martinez, Universitat Politecnica de Valencia

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Tu5F.7

Photonic-Assisted Microwave OFDM Quantum-Noise Randomized Cipher Generation via IM/DD IFoF Transmission

Presenter: Ken Tanizawa , *Tamagawa University*

We propose and demonstrate an IM/DD IF-over-Fiber system that delivers and generates OFDM quantum-noise randomized cipher for secure wireless communications. A 3.6-GHz IF 4.09-Gbit/s PSK cipher with sufficient signal masking by shot noise is generated.

Authors:Ken Tanizawa, Tamagawa University / Fumio Futami, Tamagawa University

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Tu5G

Panel: Challenges of Coherent Transponders Approaching the Shannon Limit

Tu5H

Photonic Neural Networks

Presider: S. J. Ben Yoo

Tu5H.1

A Silicon Photonic Coherent Neuron With 10GMAC/sec Processing Line-Rate

Presenter: George Mourgias-Alexandris , *Aristotle University of Thessaloniki*

We demonstrate a novel coherent Si-Pho neuron with 10Gbaud on-chip input-data vector generation capabilities. Its performance as a hidden layer within a neural network has been experimentally validated for the MNIST data-set, yielding 96.19% accuracy.

Authors:George Mourgias-Alexandris, Aristotle University of Thessaloniki / Miltiadis Moralis-Pegios, Aristotle University of Thessaloniki / Stelios Simos, Aristotle University of Thessaloniki / George Dabos, Aristotle University of Thessaloniki / Nikos Passalis, Aristotle University of Thessaloniki / Manos Kirtas, Aristotle University of Thessaloniki / Teerapat Rutirawut, Optoelectronics Research Centre / Frederic Gardes, Optoelectronics Research Centre / Anastasios tefas, Optoelectronics Research Centre / Nikos Pleros, Aristotle University of Thessaloniki

Tu5H.2

Robust Zero-Change Self-Configuration of the Rectangular Mesh

Presenter: Ryan Hamerly , *Massachusetts Institute of Technology*

We propose an algorithm to self-configure the rectangular mesh using only external sources and detectors. This procedure is robust to hardware imperfections and leads to significant accuracy improvements for optical neural networks on realistic hardware.

Authors:Ryan Hamerly, Massachusetts Institute of Technology / Saumil Bandyopadhyay, Massachusetts Institute of Technology / Dirk Englund, Massachusetts Institute of Technology

Tu5H.3

Programmable, High-Speed all-Optical Nonlinear Activation Functions for Neuromorphic Photonics

Presenter: Aashu Jha , *Princeton University*

We experimentally demonstrate programmable, all-optical nonlinear activation functions, including: rectified linear unit (ReLU), inverse-ReLU and quadratic functions, on a silicon-nitride platform at a remarkable speed of 10 Gbps, enabling real-time processing on all-purpose photonic hardware.

Authors:Aashu Jha, Princeton University / Chaoran Huang, Princeton University / Paul Prucnal, Princeton University

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Tu5H.4

High-Performance Neuromorphic Computing Based on Photonic Technologies

Invited

Presenter: Bert Offrein , *IBM Research GmbH*

Dedicated technology platforms gain interest for enhancing the performance and efficiency of neuromorphic computing. We demonstrate integrated optic devices for convolutional signal processing and neural network training.

Authors:Pascal Stark, IBM Research GmbH / Jonas Weiss, IBM Research GmbH / Roger Dangel, IBM Research GmbH / Folkert Horst, IBM Research GmbH / Jacqueline Geler Kremer, EMPA / Bert Offrein, IBM Research GmbH

Tu5H.5

Energy-Efficient Photonic Spiking Neural Network on a Monolithic Silicon CMOS Photonic Platform

Presenter: Yun-Jhu Lee , *University of California, Davis*

We designed, simulated, and taped-out a photonic spiking neural network on a monolithic silicon CMOS photonic platform. Benchmarking shows proposed PSNN outperforms other neuromorphic hardware with 21.09fJ/spike and 61.4 mW average power at MNIST experiment.

Authors:Yun-Jhu Lee, University of California, Davis / Mehmet Berkay On, University of California, Davis / Xian Xiao, University of California, Davis / S. J. Ben Yoo, University of California, Davis

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Tu5H.6

Scalable and Compact 3D Tensorized Photonic Neural Networks

Presenter: Xian Xiao , *University of California, Davis*

We propose a scalable and compact 3D tensorized photonic neural network with high-radix (1024×1024) synaptic interconnections implemented by cascaded small-radix (10×10) photonic tensor-train cores. Our architecture exhibits 6.2× lower insertion loss and 582× fewer MZIs.

Authors:Xian Xiao, University of California, Davis / S. J. Ben Yoo, University of California, Davis

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Tu5H.7
Coherent Homodyne Synaptic Interconnect With Sign- and Weight-Tunable Detection

Presenter: Bernhard Schrenk , *AIT Austrian Institute of Technology*

We experimentally investigate a synaptic interconnect with low-complexity emitter and coherent receiver. Phase tuning of the LO enables the signed multiplication of the detected signal, which is demonstrated for 130-ps spikes at 1-GHz repetition rate.

Authors:Bernhard Schrenk, AIT Austrian Institute of Technology

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Tu5I
Open Networking Summit: Towards Converged Open Packet-optical Networks

Tu5J
Optical Technologies in Data Centers

Presider: Reza Nejabati

Tu5J.1
Photonic Switching in the Datacenter

Tutorial

Presenter: Clint Schow , *University of California Santa Barbara*

This tutorial will describe current networks within datacenters and the technologies used for high-speed optical links. Paths for scaling to higher data rates, exemplary technology platforms, and co-packaged optics will be discussed to provide a framework for research directions aimed at improving the efficiency and performance of future datacenter networks.

Authors:Clint Schow, University of California Santa Barbara

Tu5J.2
Experimental Demonstration of a Nanoseconds Optical Switch Based Disaggregated Data Center Network

Presenter: Xiaotao Guo , *Eindhoven University of Technology*

A disaggregated DCN prototype based on nanoseconds optical switch is experimentally assessed. Results show a network latency of 122.3ns, no packet loss, and error-free operation with power penalty of 0.5dB at BER of 1E-9.

Authors:Xiaotao Guo, Eindhoven University of Technology / Xuwei Xue, Eindhoven University of Technology / Bitao Pan, Eindhoven University of Technology / Yu Wang, Eindhoven University of Technology / shaojuan Zhang, Eindhoven University of Technology / Georgios Exarchakos, Eindhoven University of Technology / Nicola Calabretta, Eindhoven University of Technology

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Tu5J.3

Experimental Assessments of Fast Optical Switch and Control System for Data Center Networks

Presenter: Xuwei Xue , *Eindhoven University of Technology*

A fast switch and control system is developed for the practical deployment of optical switches in DCNs. Implemented label control and OFC technique experimentally achieve zero packet-loss and 5μs server-to-server latency at 0.5 traffic load.

Authors:Xuwei Xue, Eindhoven University of Technology / Bitao Pan, Eindhoven University of Technology / Sai Chen, Alibaba Cloud / Kristif Prifti, Eindhoven University of Technology / Xiaotao Guo, Eindhoven University of Technology / Fulong Yan, Eindhoven University of Technology / Rafael Kraemer, Eindhoven University of Technology / shaojuan Zhang, Eindhoven University of Technology / Chongjin Xie, Alibaba Cloud / Nicola Calabretta, Eindhoven University of Technology

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Tu5J.4

Performance Studies of 3D-Hyper-FleX-LION for HPC Applications

Presenter: Zhiyan Liu , *University of California Davis*

This paper studies the performance of 3D-Hyper-FleX-LION for HPC systems. The simulation results obtained for different HPC applications (i.e. Fill Boundary, Crystal Router, MiniFE, and MiniDFT) show up to 2.8× improvements in throughput per watt when compared with a Fat-Tree with no oversubcription.

Authors:Zhiyan Liu, University of California Davis / Roberto Proietti, University of California Davis / Xiaoliang Chen, University of California Davis / S. J. Ben Yoo, University of California Davis

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14:00 - 16:30 Pacific Time (US & Canada) (UTC - 07:00)

Tu5A

Symposia: Emerging Photonic Technologies and Architectures for Femtojoule per Bit Optical Networks (Part 2)

Presider: Daniel Blumenthal

Tu5A.1
What Role Will Co-Packaging Play
Invited

Presenter: Vladimir Stojanovic , *Ayar Labs*

Abstract not available.

Authors:Vladimir Stojanovic, Ayar Labs

Tu5A.2
Prospects for Optical Transceivers Expanding to Access, Metro and Long-Haul
Invited

Presenter: Michael Frankel , *Ciena*

WAN transport is critical to ultra-mobile users need for access to cloud processing and content. Power
efficiency continues to improve both due to more efficient hardware and optimized resource utilization through
intelligent software and automation.

Authors:Michael Frankel, Ciena

Tu5A.3
Getting to Femtojoule Optics – What Physics and What Technology?
Invited

Presenter: David A. B. Miller , *Stanford University*

Optical physics and well-chosen intimately-integrated devices allow dense, low-energy communications if we also use optical parallelism and timing precision to eliminate most receiver, time-multiplexing and timing circuits that otherwise dissipate most of the energy.

Authors:David A. B. Miller, Stanford University

14:15 - 15:45 Pacific Time (US & Canada) (UTC - 07:00)

DCS2
Exhibit Hall Event - Data Center Summit: Inside the Data Center

14:30 - 16:00 Pacific Time (US & Canada) (UTC - 07:00)

MW3

Exhibit Hall Event - Market Watch: Terabit WDM Channels: Beyond 100GBaud Operation

16:00 - 16:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC11

Exhibit Hall Event - Technology Showcase: Parametric Measurements and Transceiver Test

16:00 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

16:30 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC12

Exhibit Hall Event - Technology Showcase: The Application of Expanded Beam Optics in the Next Generation of Data Centers

17:00 - 19:00 Pacific Time (US & Canada) (UTC - 07:00)

Tu6A

Integration in Photonic Systems

Presider: Long Chen

Tu6A.1

Simplifying Datacenter Networks With the 100G/Channel Optics Ecosystem

Invited

Presenter: Cyriel Minkenberg , *Rockley Photonics*

The intersection of a 100Gb/s/channel ecosystem for optical and electrical links in combination with emerging 512-channel switch silicon offers unprecedented potential for simplifying datacenter network architectures.

Authors:Cyriel Minkenberg, Rockley Photonics

Tu6A.2

Fully-Loaded Operation of 0.29-pJ/bit Wall-Plug Efficiency, 81.9-Tb/s Throughput 32×32 Silicon Photonics Switch

Presenter: Ryosuke Matsumoto , *National Institute of Advanced Industria*

We demonstrate 16-ch.×32-Gbaud QPSK/probabilistically-shaped-64QAM WDM transmission by three/nine cyclic propagations through a fully-loaded 32×32 silicon photonics switch. Its nine-stage Clos network will have a throughput of 125 Pb/s (131,072 ports × 0.952 Tb/s).

Authors:Ryosuke Matsumoto, National Institute of Advanced Industria / Ryotaro Konoike, National Institute of Advanced Industria / Keijiro Suzuki, National Institute of Advanced Industria / Hiroyuki Matsuura, National Institute of Advanced Industria / Kazuhiro Ikeda, National Institute of Advanced Industria / Takashi Inoue, National Institute of Advanced Industria / Shu Namiki, National Institute of Advanced Industria

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Tu6A.3

Demonstration of Crosstalk-Free WDM Demultiplexing on Si Nanowire PIC Controlled by Si CMOS ASIC

Presenter: Tomoyuki Akiyama , *PETRA*

We demonstrate fully automatic suppression of crosstalk, inevitable in WDM demultiplexers on Si nanowire PIC. This is realized with a low-cost CMOS ASIC dedicatedly designed for low-power control of our proposed CAT demultiplexer. It is shown to have zero OSNR penalty even under continuous control required to cancel dynamic environmental change.

Authors:Tomoyuki Akiyama, PETRA / Motoyuki Nishizawa, PETRA / Akio Sugama, PETRA / Yasuhiro Nakasha, PETRA / Shinsuke Tanaka, Fujitsu Limited / Yu Tanaka, PETRA / Shoichiro Oda, Fujitsu Limited / Takeshi Hoshida, Fujitsu Limited

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Tu6A.4

Polarization-Transparent FSR-Free Microring Resonator Filter With Wide Hitless Tunability

Presenter: Maziyar Milanizadeh , *politecnico di milano*

A coupled microring resonator architecture with non-integer Vernier ratio design and controllable loss is exploited to implement a polarization-transparent hitless tunable FSR-free filter operating over the extended C+L band (1520 nm–1620 nm).

Authors:Maziyar Milanizadeh, politecnico di milano / Matteo Petrini, politecnico di milano / Francesco Morichetti, politecnico di milano / Andrea Melloni, politecnico di milano

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Tu6A.5

Integrated Photonic Interrogator With on-Chip References

Presenter: Glen Koste , *GE Research*

We describe a silicon integrated photonic interrogator with on-chip wavelength and temperature referencing for absolute measurements. We demonstrate fiber Bragg grating interrogation with ±1^{o}C temperature accuracy without thermo-electric coolers.

Authors:Glen Koste, GE Research / Baokai Cheng, GE Research / Loucas Tsakalakos, GE Research

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Tu6A.6

Device Response Time Reduction for Large-Scale and Fast Optical Switching Systems

Presenter: Kenya Suzuki , *Photonics Electronics Technology Research Association (PETRA)*

We reduced transient response times of a practically used switch element, wavelength- tunable laser, and DSP—key components of optical switching systems—with 1000-port-class scalability and 100-μs order switching time for datacenter applications.

Authors:Kenya Suzuki, Photonics Electronics Technology Research Association (PETRA) / Kazushige Yonenaga, Photonics Electronics Technology Research Association (PETRA) / Noboru Takachio, Photonics Electronics Technology Research Association (PETRA) / Toshiki Tanaka, Photonics Electronics Technology Research Association (PETRA) / Osamu Moriwaki, Photonics Electronics Technology Research Association (PETRA) / Hiroshi Onaka, Photonics Electronics Technology Research Association (PETRA)

Tu6B

Multi-core Fibers 1

Presider: Tetsuya Hayashi

Tu6B.1

Multi-Core Fiber Technology for SDM: Coupling Mechanisms and Design

Tutorial

Presenter: Kunimasa Saitoh , *Hokkaido University*

This tutorial will describe coupling mechanism and design issues in multi-core fibers for SDM. The effect of random perturbations on the inter-core crosstalk in uncoupled MCFs and modal dispersion in coupled MCFs will be discussed.

Authors:Kunimasa Saitoh, Hokkaido University

Tu6B.2

Optical Fiber Cable Employing 200 µm-Coated Multicore Fibers for High Density Wiring in Datacom

Presenter: Yusuke Sasaki , *Fujikura Ltd.*

An optical fiber cable employing 200 µm coated 4-core fibers was fabricated and confirmed to satisfy the characteristics required for conventional cables. 200 µm coating multicore fibers are promising candidates for ultra-high density cables.

Authors:Yusuke Sasaki, Fujikura Ltd. / Ryohei Fukumoto, Fujikura Ltd. / Katsuhiro Takenaga, Fujikura Ltd. / Shogo Shimizu, Fujikura Ltd. / Kazuhiko Aikawa, Fujikura Ltd.

Tu6B.3

GAWBS Noise Correlation Between Cores in Four-Core Fiber

Presenter: Kozo Sato , *Tohoku University*

We describe the correlation between GAWBS noise in each core in four-core fiber both experimentally and analytically. The correlation of $TR_{n,m}$ modes in each core was found to depend strongly on the order-*n* and birefringence.

Authors:Kozo Sato, Tohoku University / Masato Yoshida, Tohoku University / Keisuke Kasai, Tohoku University / Toshihiko Hirooka, Tohoku University / Masataka Nakazawa, Tohoku University

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Tu6B.4

Standard Cladding Diameter Multi-Core Fiber Technology

Invited

Presenter: Takashi Matsui , *NTT Corporation*

We show progress of standard 125 µm-cladding multi-core fiber (MCF) technology for cable deployment and its standardization. Its application space and geometrical requirements are described by considering compatibility with existing fiber standards to realize inter-operability.

Authors:Takashi Matsui, NTT Corporation / Yusuke Yamada, NTT Corporation / Yuto Sagae, NTT Corporation / Kazuhide Nakajim, NTT Corporation

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Tu6C

Novel Sensors and Applications

Presider: Joel Villatoro

Tu6C.1

Meeting Industrial Needs With Optical Fibre Sensors

Invited

Presenter: K. Grattan , *City University*

Optical Fiber Sensor technology has shown major developments recently, especially in uses across a range of different industrial measurement situations. Several illustrative applications are considered, with the benefits and outcomes of their use reviewed.

Authors:K. Grattan, City University / Tong Sun, City University

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Tu6C.2

Monitoring the Red Palm Weevil Infestation Using Machine Learning and Optical Sensing

Presenter: Yuan MAO , *King Abdullah Universityof Science and Technology (KAUST)*

Red palm weevil (RPW) has destroyed many palm farms worldwide. Early detection of RPW is challenging. We introduce combining machine learning and fiber optic distributed acoustic sensing for detecting the RPW in its larvae stage.

Authors:Yuan MAO, King Abdullah Universityof Science and Technology (KAUST) / Islam Ashry, King Abdullah Universityof Science and Technology (KAUST) / Biwei Wang, King Abdullah Universityof Science and Technology (KAUST) / Yousef Al-Fehaid, Ministry of Environment, Water and Agriculture / Abdulmoneim Al-Shawaf, Ministry of Environment, Water and Agriculture / Tien Khee Ng, King Abdullah Universityof Science and Technology (KAUST) / Changyuan Yu, The Hong Kong Polytechnic University / Boon Ooi, King Abdullah Universityof Science and Technology (KAUST)

Tu6C.3

Inchworm-Inspired Soft Robotic Climber With Embedded Fiber Optic Sensors

Presenter: Mei Yang , *University of Georgia*

An inchworm-inspired soft robotic climber with three embedded fiber Bragg grating sensors in the body is proposed and demonstrated. The grating sensors monitor the unique locomotion status of the climber for precise feedback and control.

Authors:Mei Yang, University of Georgia / Liam Cooper, University of Georgia / Sammanth Vo, University of Georgia / Mable Fok, University of Georgia

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Tu6C.4

Fiber Optic Sensor Network for a Monitoring and Diagnosis System of the Underground 22.9K XLPE Cable

Presenter: Si Woong Park , *Electronics and Telecommunications Research Institute*

For monitoring of the underground power cables, we proposed an optical sensor network. When the surface temperature of the power cable has increased from about 40 °C we confirmed partial discharge amplitude was significantly reduced.

Authors:Si Woong Park, Electronics and Telecommunications Research Institute / Chan Il Yeo, Electronics and Telecommunications Research Institute / hyun jin kim, Electronics and Telecommunications Research Institute / Hyun Seo Kang, Electronics and Telecommunications Research Institute / In jin Seo, KEPCO Research Institute / Hyoung Jun Park, Electronics and Telecommunications Research Institute

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Tu6C.5

Photonic Sensor and Miniature Interrogator Based on Cascaded Silicon Microring Resonators

Presenter: fan yang , *Shanghai Jiao Tong University*

We experimentally demonstrate a novel DBS interrogation technique for mono-lithic refractive index sensing and interrogating using cascaded microring resonators. Thesensitivity is 125.1 nm/RIU and resolution is 7.76×10^{-6} RIU

Authors:fan yang, Shanghai Jiao Tong University / Wenjia Zhang, Shanghai Jiao Tong University / Yue Jiang, Shanghai Jiao Tong University / Jifang Tao, Shandong University / Zuyuan He, Shanghai Jiao Tong University

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Tu6C.6

Sensitivity Improvement for Silicon MS-SW BG Sensors by Waveguide Height Increase or by Waveguide Suspension With Supporting Shape Modification

Presenter: Siim Heinsalu , *Waseda University*

Two methods for refractive index sensitivity improvement of silicon SW-MS BG refractive index sensors were considered. Height parameter was optimized and suspended waveguides were introduced. Experimentally obtained values were 850 nm/RIU and 1100 nm/RIU, respectively.

Authors:Siim Heinsalu, Waseda University / Anna Kawano, Waseda University / Yushi Isogai, Waseda University / Yuichi Matsushima, Waseda University / Hiroshi Ishikawa, Waseda University / Katsuyuki Utaka, Waseda University

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Tu6C.7

A Hybrid Coating Based Fiber Probe for Ultrasound Generation and Detection

Presenter: Dongchen Xu , *Huazhong Univ of Science and Technology*

We demonstrated a hybrid coating based fiber probe for simultaneous ultrasound generation and detection. The probe exhibits a generated pressure of 864kPa and a bandwidth about 25MHz, as well as a high sensitivity of 3.41V/MPa.

Authors:Dongchen Xu, Huazhong Univ of Science and Technology / Liuyang Yang, Huazhong Univ of Science and Technology / Fang Fang, Huazhong Univ of Science and Technology / Geng Chen, Huazhong Univ of Science and Technology / Yanpeng Li, Huazhong Univ of Science and Technology / Qizhen Sun, Huazhong Univ of Science and Technology

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Tu6D

High-speed and Real-time Coherent Systems

Presider: Takahito Tanimura

Tu6D.1

Beyond 1 Tbit/s Transmission Using High-Speed DACs and Analog Multiplexing

Tutorial

Presenter: Fred Buchali , *Nokia Bell Labs*

Today's research has demonstrated the highest bit rates, already well beyond 1 Tb/s per wavelength. These rates are required to support relentless capacity growth. This tutorial will cover the underlying transponder technology and discuss the latest developments on DACs and AMUX.

Authors:Fred Buchali, Nokia Bell Labs

Tu6D.2

Real-Time 100.4 GBd PCS-64QAM Transmission of a 1.6 Tb/s Super-Channel Over 1600 km of G.654.E Fiber

Presenter: Robert Maher , *Infinera Corporation*

First demonstration of a real-time 100.4 GBd PCS-64QAM 2x800G coherent MODEM. A record transmission distance of 1600 km is achieved for a dual-carrier 1.6 Tb/s channel over a fully loaded commercial line system, with an OSNR margin in excess of 2 dB to the FEC threshold.

Authors:Robert Maher, Infinera Corporation / Mohammad Chitgarha, Infinera Corporation / Irene Leung, Infinera Corporation / Amir Rashidinejad, Infinera Corporation / Brandon Buscaino, Infinera Corporation / Zhenxing Wang, Infinera Corporation / Mehdi Torbatian, Infinera Corporation / Aditya Kakkar, Infinera Corporation / Ziad Elsahn, Infinera Corporation / Mohamed Osman, Infinera Corporation / Ales Kumpera, Infinera Corporation / Reza Nejad, Infinera Corporation / Amin Yekani, Infinera Corporation / George Soliman, Infinera Corporation / Clayton Doggart, Infinera Corporation / Miguel Olmedo, Infinera Corporation / Samantha Kerns, Infinera Corporation / Julio Diniz, Infinera Corporation / Zulfikar Morbi, Infinera Corporation / Swen Koenig, Infinera Corporation / Lee Dardis, Infinera Corporation / Bryan Ellis, Infinera Corporation / Alban Le Liepvre, Infinera Corporation / Mark Missey, Infinera Corporation / Stanley Blakey, Infinera Corporation / Yuejian Wu, Infinera Corporation / Parmijit Samra, Infinera Corporation / Vince Dominic, Infinera Corporation / Sergejs Makovejs, Corning / Vikrant Lal, Infinera Corporation / Mehrdad Ziari, Infinera Corporation / Han Henry Sun, Infinera Corporation / Kuang-Tsan Wu, Infinera Corporation / Steve Sanders, Infinera Corporation / Parthiban Kandappan, Infinera Corporation

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Tu6D.3

Real-Time 400G CFP2-DCO Using 69GBaud/DP-16QAM-PS Over 1000km 75GHz-Spaced DWDM Systems

Presenter: You-Wei Chen , *NeoPhotonics*

A <26.5W pluggable CFP2-DCO module using 69 Gbaud/DP-16QAM-PS is demonstrated for the first time to carry a net 424.9 Gb/s over a 75GHz-spaced 1000km DWDM link with a 4.5-dB OSNR margin.

Authors:You-Wei Chen, NeoPhotonics / Shaoyun Yi, NeoPhotonics / Gang Ling, NeoPhotonics / Brian West, NeoPhotonics / Liang Zhao, NeoPhotonics / Winston I. Way, NeoPhotonics

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Tu6D.4

FPGA Implementation of Hierarchical Subcarrier Rate and Distribution Matching for up to 1.032 Tb/s or 262144-QAM

Presenter: Tsuyoshi Yoshida , *Mitsubishi Electric Corporation*

A novel hierarchical subcarrier rate and distribution matching has been implemented in an FPGA at 1.032 Tb/s. The implemented subsystem achieves seamless data flow among subcarriers at a resolution < 0.01 bit per channel use.

Authors:Tsuyoshi Yoshida, Mitsubishi Electric Corporation / Koji Igarashi, Osaka University / Yoshiaki Konishi, Mitsubishi Electric Corporation / Magnus Karlsson, Chalmers University of Technology / Erik Agrell, Chalmers University of Technology

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Tu6D.5

Real Time FPGA Investigation of Probabilistic Shaping 16QAM With HiDM and OFEC

Presenter: Liangjun Zhang , *ZTE*

We investigate a PS-16QAM scheme employing HiDM and oFEC with FPGA implementation. By measuring BERs down to 10^{-15}, we demonstrate that the PS scheme does not degrade the decoding performance of oFEC.

Authors:Liangjun Zhang, ZTE / Weiming Wang, ZTE / Weifeng Qian, ZTE / Kai Tao, ZTE / Yi Cai, ZTE

Tu6E
Systems for 5G and Beyond

Presider: Volker Jungnickel

Tu6E.1

High-Speed and Wide Fov Autonomous Beamformer Driving Forward to 4D Resource Allocation in 6G RAN Era

Invited

Presenter: You-Wei Chen , *Georgia Institute of Technology*

We summarized recent progresses of the proposed analog IF beamformer in a fiber-wireless integration and network (FiWIN) architecture. Besides, intra- and inter-beam NOMA systems are designed and experimentally demonstrated to form 4D multiple access structure.

Authors:You-Wei Chen, Georgia Institute of Technology / Shang-Jen Su, Georgia Institute of Technology / CHIN-WEI HSU, Georgia Institute of Technology / Min-Yu Huang, Georgia Institute of Technology / Hua Wang, Georgia Institute of Technology / Gee-Kung Chang, Georgia Institute of Technology

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Tu6E.2

64 Gbit/s, 256 QAM Transmission Through Coherent Optical-Wireless Link at 61 GHz Using Simple and High OSNR Carrier Frequency Converter

Presenter: Keisuke Kasai , *Tohoku University*

We demonstrate a coherently-linked optical-wireless transmission in the 61 GHz band using a simple and high-performance injection-locking-based carrier-frequency converter. 64 Gbit/s, 256 QAM data were transmitted over a 10 km-SMF and over 40 m wirelessly.

Authors:Keisuke Kasai, Tohoku University / Taisei Sato, Tohoku University / Toshihiko Hirooka, Tohoku University / Masato Yoshida, Tohoku University / Masataka Nakazawa, Tohoku University

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Tu6E.3

3×3 MIMO 60-GHz Direct-Detection OFDM RoFMF System With Mitigation of Optical Carrier Power Fading

Presenter: SHAO-HUNG YU , *National Chiao Tung University*

We propose a novel method to mitigate the power fading effect in a V-band fiber-wireless 3x3 MIMO system. The proposed scheme can realize the 114.71-Gbps RoFMF system with 1.7-m FMF and 3-m wireless transmission.

Authors:Ping-Yao Huang, National Chiao Tung University / Zhen-Xiong Xie, National Chiao Tung University / Tung-Han Hsieh, National Chiao Tung University / SHAO-HUNG YU, National Chiao Tung University / Chia Chien Wei, National Sun Yat-sen University / Chun-Ting Lin, National Chiao Tung University / Sien Chi, National Chiao Tung University

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Tu6E.4

High-Performance Four-Channel Analog Optical Transceiver for 5G ARoF-Based Mobile Fronthaul.

Presenter: Haiping Song , *Huazhong University of Sci. and Techn.*

A high-performance 4-channel DML-based analog optical transceiver is designed, and novel impedance-matching using 40-ohm TFR nested in AlN-carrier is proposed. The EVM of 4×600Mbit/s LTE-64QAM-OFDM signal with carrier-frequency from 2-12GHz over 15.5km SSMF is <3.2%.

Authors:Haiping Song, Huazhong University of Sci. and Techn. / Mengyao Ai, Wuhan Research Institute Post & Telecommunications / Runze Hu, Huazhong University of Sci. and Techn. / Zhe Fu, Huazhong University of Sci. and Techn. / Li Di, Huazhong University of Sci. and Techn. / megnfan cheng, Huazhong University of Sci. and Techn. / deming liu, Huazhong University of Sci. and Techn. / lei deng, Huazhong University of Sci. and Techn.

Tu6E.5

NOMA-CoMP for 5G MMW Fiber Wireless Integration Fronthaul System With SFBC

Presenter: Jhih-Heng Yan , *National Tsing Hua University*

NOMA-CoMP based space frequency block coding is firstly proposed and experimentally demonstrated for 28 GHz MMW fiber wireless integration fronthaul system. The end-to-end experiment reveals enhanced cell edge user signal quality and improved spectral efficiency.

Authors:Jhih-Heng Yan, National Tsing Hua University / Jin-Wei Hsu, National Tsing Hua University / Jian-Kai Huang, National Tsing Hua University / Yu-Yang Lin, National Tsing Hua University / Kai-Ming Feng, National Tsing Hua University

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Tu6F

Fiber Sensing in Telecom Fiber Networks

Presider: Mei Du

Tu6F.1

Fiber Sensing in Existing Telecom Fiber Networks

Tutorial

Presenter: Glenn Wellbrock , *Verizon Communications Inc*

Abstract not available.

Authors:Glenn Wellbrock, Verizon Communications Inc

Tu6F.2

Distributed Fiber Sensor Network Using Telecom Cables as Sensing Media: Technology Advancements and Applications

Invited

Presenter: Ezra Ip , *NEC Laboratories America Inc*

Distributed fiber optical systems (DFOS) allow deployed optical cables to monitor the ambient environment over wide geographic area. We review recent field trial results, and show how DFOS can be made compatible with passive optical networks (PONs).

Authors:Ezra Ip, NEC Laboratories America Inc / Yue-Kai Huang, NEC Laboratories America Inc / Ming-Fang Huang, NEC Laboratories America Inc / Milad Salemi, NEC Laboratories America Inc / Yaowen Li, NEC Laboratories America Inc / Ting Wang, NEC Laboratories America Inc / Yoshiaki Aono, NEC Corporation / Glenn Wellbrock, Verizon / Tiejun Xia, Verizon

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Tu6F.3

Static Weight Detection and Localization on Aerial Fiber Cables Using Distributed Acoustic Sensing

Presenter: Sarper Ozharar , *NEC Labs America*

We demonstrated for the first time to our knowledge, the detection and localization of a static weight on an aerial cable by using frequency domain decomposition analysis of ambient vibrations detected by a φ-DAS system.

Authors:Sarper Ozharar, NEC Labs America / Yangmin DIng, NEC Labs America / Yue Tian, NEC Labs America / Ting Wang, NEC Labs America / Yukihide Yoda, NEC Corporation / Yoshiaki Aono, NEC Corporation

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19:00 - 20:30 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

Wednesday, 09 June

3:00 - 5:00 Pacific Time (US & Canada) (UTC - 07:00)

W1A

Optical Switching and Network Devices

Presider: Richard Jensen

W1A.1

Wavelength Selective Switch Components With High Spectral Resolution and Compactness

Invited

Presenter: Haoshuo Chen , *Nokia Bell Labs*

We review the wavelength selective switch (WSS) for ultra-broadband transmission and spatial division multiplexing. We also discuss and present experimental results of WSS components with high spectral resolution and compactness.

Authors:Haoshuo Chen, Nokia Bell Labs / Nicolas Fontaine, Nokia Bell Labs / Mikael Mazur, Nokia Bell Labs / Roland Ryf, Nokia Bell Labs / David Neilson, Nokia Bell Labs / Qingguo Song, Huazhong University of science and technology / Zhijun Yan, Huazhong University of science and technology

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W1A.2

Integrated Tunable Sideband Suppressor for Application of Remote Optical Carrier Reuse

Presenter: Ming-Chang Lee , *National Tsing Hua University*

An integrated tunable double sideband suppressor based on a two-rings-assisted Mach Zehnder interferometer is presented for remote optical carrier reuse. We demonstrate a suppression ratio more than 15 dB for both 28GHz and 39GHz mmWave transmission.

Authors:Yi-Hsuan Chen, National Tsing Hua University / Kuan-Heng Chen, National Tsing Hua University / Jhih-Heng Yan, Chunghwa Teclcom Co., Ltd / The Anh Nguyen, National Tsing Hua University / Kai-Ming Feng, National Tsing Hua University / Ming-Chang Lee, National Tsing Hua University

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W1A.3

Ultra-Wideband and Low-Loss Core Selective Switch Employing Two-Dimensionally Arranged MEMS Mirrors

Presenter: Masahiko Jinno , *Kagawa University*

We experimentally show an ultra-wideband (130 nm), compact (~50 mm), low insertion loss (< 2.7 dB), and low-polarization-dependent-loss (< 0.25 dB) five-core 1×8 core selective switch employing a two-dimensionally arranged MEMS array.

Authors:Masahiko Jinno, Kagawa University / Itsuki Urashima, Kagawa University / Tsubasa Ishikawa, Kagawa University / Takahiro Kodama, Kagawa University

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W1A.4

5.5%-Δ-PLC/Silicon Photonics Hybrid Wavelength MUX/DEMUX-and-Switch Device

Presenter: Kazuhiro Ikeda , *National Institute of Advanced Industrial Science and Technology*

We propose a novel hybrid integration scheme by demonstrating a polarization-insensitive low-crosstalk 8 × 8 silicon photonics switch butt-jointed with a compact extremely-high-Δ SiO_2-ZrO_2-based 100-GHz 8-ch AWG, which exploits performance advantages of each platform.

Authors:Kazuhiro Ikeda, National Institute of Advanced Industrial Science and Technology / Noritaka Matsubara, Furukawa Electric Co., Ltd. / Junichi Hasegawa, Furukawa Electric Co., Ltd. / Ryotaro Konoike, National Institute of Advanced Industrial Science and Technology / Hiroyuki Matsuura, National Institute of Advanced Industrial Science and Technology / Keijiro Suzuki, National Institute of Advanced Industrial Science and Technology / Hitoshi Kawashima, National Institute of Advanced Industrial Science and Technology

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W1A.5

Wavelength Selective Switches for SDM Photonic Nodes Based on SPOC Platform

Invited

Presenter: Seno Kazunori , *NTT Corporation*

We overview wavelength selective switches for space-division multiplexing (SDM) nodes. The space and planar optical circuit (SPOC) platform is suitable for integration of multiple WSSs into a single module, which is suitable for SDM systems.

Authors:Seno Kazunori, NTT Corporation / Naru Nemoto, NTT Corporation / Yutaka Miyamoto, NTT Corporation

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W1A.6

Fast Optical Switch Utilizing Coherent Detection Enabled by Cooperative Filtering of Transmission Signal and Local Oscillator (LO) Wavelength Sourced From an LO Bank

Presenter: Ryosuke Matsumoto , *National Institute of Advanced Industria*

We propose cooperative filtering scheme for transmission signals and LO channels from an LO bank; this yields 50% filter chip-size reduction and fast (3.2μs) switching. 1,856×1,856 optical switching of 128-Gb/s DP-QPSK signals is successfully demonstrated.

Authors:Ryosuke Matsumoto, National Institute of Advanced Industria / Ryotaro Konoike, National Institute of Advanced Industria / Hiroyuki Matsuura, National Institute of Advanced Industria / Keijiro Suzuki, National Institute of Advanced Industria / Takashi Inoue, National Institute of Advanced Industria / Kazuhiro Ikeda, National Institute of Advanced Industria / Shu Namiki, National Institute of Advanced Industria / Ken-ichi Sato, National Institute of Advanced Industria

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W1B

High-performance CW Lasers

Presider: Geert Morthier

W1B.1

AlGaInAs MQW Laser Regrowth on Heterogenerous InP-on-SOI : Performance for Different Silicon Cavity Designs

Presenter: Claire Besancon *, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI*

Vertical p-i-n lasers integrated by wafer-bonding and regrowth on a heterogeneous InP-on-SOI wafer are presented. We demonstrate for the first time lasers based on regrown III-V active regions efficiently coupled to Si-photonic DBR cavities.

Authors:Claire Besancon, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / Delphine Néel, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / Joan Ramirez, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / David Bitauld, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / Giancarlo Cerulo, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / Dalila Make, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / Nicolas Vaissiere, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / Frederic Pommereau, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI / Frank Fournel, University Grenoble Alpes, CEA LETI / Loic Sanchez, University Grenoble Alpes, CEA LETI / Cécilia Dupré, University Grenoble Alpes, CEA LETI / Viviane Muffato, University Grenoble Alpes, CEA LETI / Karim Hassan, University Grenoble Alpes, CEA LETI / Jean Decobert, III-V Lab, a joint lab of Nokia Bell Labs, Thales Research and Technology and CEA LETI

W1B.2

8-ch, 160-nm-Wavelength-Range Membrane Laser Array Using Selective Epitaxy on InP-on-Insulator Substrate

Presenter: Takuro Fujii , *NTT Device Technology Labs*

We fabricate an 8-ch 160-nm-range membrane laser array with selectively grown InGaAlAs-MQWs on a thin InP layer on SiO_2/Si. By controlling the material gain peak and lasing wavelength, all lasers exhibit 32-Gbit/s NRZ direct modulation.

Authors:Takuro Fujii, NTT Device Technology Labs / Tomonari Sato, NTT Device Technology Labs / Nikolaos-Panteleimon Diamantopoulos, NTT Device Technology Labs / Koji Takeda, NTT Device Technology Labs / Hidetaka Nishi, NTT Device Technology Labs / Takuma Tsurugaya, NTT Device Technology Labs / Tai Tsuchizawa, NTT Device Technology Labs / Shinji Matsuo, NTT Device Technology Labs

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W1B.3

Integrated Coherent Tunable Laser (ICTL) With 118 nm Tuning Range and sub-100 Hz Lorentzian Linewidth

Presenter: Paul Morton , *Morton Photonics Inc.*

Silicon Photonics foundry based Integrated Coherent Tunable Laser (ICTL) devices display record performance; 118 nm wavelength tuning covering S-, C- and L-bands, Lorentzian linewidths below 100 Hz, and -155 dBc/Hz relative intensity noise.

Authors:Paul Morton, Morton Photonics Inc. / Chao Xiang, University of California at Santa Barbara / Jacob Khurgin, Johns Hopkins University / Christopher Morton, Morton Photonics Inc. / Minh Tran, University of California at Santa Barbara / Jon Peters, University of California at Santa Barbara / Joel Guo, University of California at Santa Barbara / Michael Morton, Morton Photonics Inc. / John Bowers, University of California at Santa Barbara

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W1B.4

Non-Abelian Gauge Fields With Fiber Optics and Beyond

Invited

Presenter: Yi Yang , *Massachusetts Institute of Technology*

We observe the non-Abelian Aharonov–Bohm effect by synthesizing nonAbelian gauge fields in a fiber-optic interferometer, enabled by multiple time-reversal symmetry breaking in orthogonal bases of the Hilbert space. Based on the realized building blocks of non-Abelian gauge fields, We introduce and study a type of non-Abelian Hofstadter models.

Authors:Yi Yang, Massachusetts Institute of Technology / Marin Soljacic, Massachusetts Institute of Technology

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W1B.5

Narrow Linewidth and low Thermal Tuning Power Thermally Tuned Multi-Channel Interference Widely Tunable Semiconductor Laser

Presenter: Kuankuan Wang , *WNLO*

The high-performance thermally tuned multi-channel interference widely tunable semiconductor laser was demonstrated for the first time, achieving tuning range of more than 60nm, SMSRs of more than 44dB and Lorentzian linewidth of less than 100kHz.

Authors:Kuankuan Wang, WNLO / Quanan Chen, WNLO / Chun Jiang, WNLO / Zifeng Chen, WNLO / Qiaoyin Lu, WNLO / Weihua Guo, WNLO

W1B.6

Tunable DBR Laser With Integrated Optical Isolator

Presenter: Hauke Conradi , *Fraunhofer Heinrich Hertz Institute*

Integration of a tunable DBR laser with an optical isolator in a polymer platform achieves 38 dB isolation over 17 nm tuning range and 5.6 mW output power. Device size is 2 x 6 mm2.

Authors:Hauke Conradi, Fraunhofer Heinrich Hertz Institute / Tianwen Qian, Fraunhofer Heinrich Hertz Institute / Martin Kresse, Fraunhofer Heinrich Hertz Institute / Jakob Reck, Fraunhofer Heinrich Hertz Institute / David de Felipe, Fraunhofer Heinrich Hertz Institute / Moritz Kleinert, Fraunhofer Heinrich Hertz Institute / Madeleine Weigel, Fraunhofer Heinrich Hertz Institute / Crispin Zawadzki, Fraunhofer Heinrich Hertz Institute / Norbert Keil, Fraunhofer Heinrich Hertz Institute / Martin Schell, Fraunhofer Heinrich Hertz Institute

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W1B.7

Record-High Power 1.55-μm Distributed Feedback Laser Diodes for Optical Communication

Presenter: Yuanfeng Mao , *Huawei Technologies Co., Ltd.*

We demonstrate the first slab-coupled optical waveguide DFB laser diodes at C/C+ bands. Record-high kink-free CW output power of 850 mW and low divergence angle of 10.7° × 16.8° are simultaneously realized.

Authors:Yuanfeng Mao, Huawei Technologies Co., Ltd. / Yuanbing Cheng, Huawei Technologies Co., Ltd. / Benbo Xu, Huawei Technologies Co., Ltd. / Ruiqiang Ji, Huawei Technologies Co., Ltd. / Yanbo Li, Huawei Technologies Co., Ltd.

W1C
Photonic Switching and Communications

Presider: Mitsuru Takenaka

W1C.1

140 Gb/s WDM Data Routing in a Lossless Strictly Non-Blocking SOA-Based Photonic Integrated 8×8 Space Switch

Presenter: Desalegn Wolde Feyisa , *Eindhoven university of Technology*

We demonstrate 4×35 Gbps error-free WDM data routing in a lossless compact 8×8 InP optical space switch with 2 dB worst-case penalty. 10 dB IPDR within 1.5 dB power penalty is measured at 12.5 Gbps.

Authors:Desalegn Wolde Feyisa, Eindhoven university of Technology / Bin Shi, Eindhoven university of Technology / Barry Smalbrugge, Eindhoven university of Technology / Kevin Williams, Eindhoven university of Technology / Nicola Calabretta, Eindhoven university of Technology / Ripalta Stabile, Eindhoven university of Technology

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W1C.2

All-Optical Switching With Graphene-Loaded Plasmonic Waveguides in the Femtojoule and Femtosecond Range

Invited

Presenter: Masaaki Ono , *NTT Corporation*

Graphene's ultrafast carrier response enables ultrafast device operation, but its thinness makes graphene devices large and energy consuming. Introducing plasmonic nanostructures overcomes this problem and makes it possible to develop ultrafast, energy-efficient all-optical switches.

Authors:Masaaki Ono, NTT Corporation / Masanori Hata, NTT Corporation / Masato Tsunekawa, NTT Corporation / Kengo Nozaki, NTT Corporation / Hisashi Sumikura, NTT Corporation / Hisashi Chiba, NTT Corporation / Masaya Notomi, NTT Corporation

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W1C.3

Self-Homodyne Photonic Transmitter in a Monolithic InP Platform for RF Applications

Presenter: Michael Hoff , *Georgia Institute of Technology*

We demonstrate for the first time a self-homodyne transmitter architecture, compactly realized as a monolithic InP system-on-chip analog photonic integrated circuit, with RF gain improvement >10 dB by using an actively-tuned optical bypass.

Authors:Michael Hoff, Georgia Institute of Technology / Christian Bottenfield, Georgia Institute of Technology / Varghese Thomas, Georgia Institute of Technology / Ardy Winoto, Infinera Inc / Yuchun Zhou, Infinera Inc / Ashish Bhardwaj, Infinera Inc / Gloria Hoefler, Infinera Inc / Stephen Ralph, Georgia Institute of Technology

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W1C.4

2D Grating Coupler Induced Polarization Crosstalk in Coherent Transceivers for Next Generation Data Center Interconnects

Presenter: Galina Georgieva , *Technische Universität Berlin*

We investigate fundamental properties of polarization-splitting/combining 2D grating couplers for silicon photonic coherent transceivers. Linear cross-polarization related polarization crosstalk causes signal non-orthogonality. The relevance of these effects is illustrated in a 16-QAM experiment.

Authors:Galina Georgieva, Technische Universität Berlin / Pascal Seiler, Technische Universität Berlin / Christian Mai, IHP GmbH - Leibnitz Institut für innovative Mikroelektronik / Klaus Petermann, Technische Universität Berlin / Lars Zimmermann, Technische Universität Berlin

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W1D

Novel Fiber and Waveguide Based Devices

Presider: Hidehisa Tazawa

W1D.1

Silicon-Photonics-Based Spectroscopic Sensing for Environmental Monitoring and Health Care

Tutorial

Presenter: Roel G. Baets , *Ghent University - IMEC*

Spectroscopic sensing is a powerful modality for numerous applications in medicine, biotechnology and structural health monitoring. Often the implementation is bulky or costly, which is a barrier for high volume markets. Integrated photonics - in particular silicon and silicon nitride photonics - is changing this and will boost spectroscopic sensing to such markets, for example in personalized medicine. This tutorial will discuss underlying principles, technologies and application cases.

Authors:Roel G. Baets, Ghent University - IMEC

W1D.2

Meta-Objective With sub-Micrometer Resolution for Microendoscopes

Presenter: Jianwen Dong , *Sun Yat-sen University*

We propose a meta-objective based on cascaded metalens, which can achieve sub-micrometer resolution in wide field of view. Combined with fiber bundle microscope system, the single cell contour of biological tissue can be clearly observed.

Authors:Yan Liu, Sun Yat-sen University / Qing-Yun Yu, Sun Yat-sen University / Ze-Ming Chen, Sun Yat-sen University / Hao-Yang Qiu, Sun Yat-sen University / Rui Chen, Sun Yat-sen University / Shao-Ji Jiang, Sun Yat-sen University / Xin-Tao He, Sun Yat-sen University / Fu-Li Zhao, Sun Yat-sen University / Jianwen Dong, Sun Yat-sen University

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W1D.3

Solid-State VCSEL Beam Scanner With Ultra-Large Field of View and High Resolution

Presenter: Ruixiao Li , *Tokyo Institute of Technology*

A solid-state counter-propagation beam scanner was demonstrated. By introducing a one-dimensional DOE, we realized ultra-large field-of-view of 132°×14° and produced record number of resolution points of more than 1800.

Authors:Ruixiao Li, Tokyo Institute of Technology / Zeuku Ho, Tokyo Institute of Technology / Xiaodong Gu, Tokyo Institute of Technology / Satoshi Shinada, National Institute of Information and Communications Technology / Fumio Koyama, Tokyo Institute of Technology

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W1D.4

Optical-Phased Array Beam-Steering Using Multi-Input Slab Coupler in Silicon Nitride Waveguides

Presenter: Pascual Muñoz , *Universitat Politècnica de València*

A 2D beam-steering optical phased array is demonstrated in SiN. The multiple-input slab-coupler reduces OPA footprint 8x versus previous single-input designs. Measured field of view is 15° x 2.8°. Gaussian beam full-width is 0.36° x 0.175°

Authors:Pascual Muñoz, Universitat Politècnica de València / Daniel Pastor, Universitat Politècnica de València / Jesús Benítez, Universitat Politècnica de València / Gloria Micó, Universitat Politècnica de València / Luis Bru, Universitat Politècnica de València / Dominic Goodwill, Huawei Canada Co., Ltd. / Eric Bernier, Huawei Canada Co., Ltd.

W1D.5

Uniform Emission of Large-Scale Optical Phase Arrays With Wide Wavelength Tuning

Presenter: Hongjie Wang , *The Chinese University of Hong Kong (CUHK), Shenzhen*

We demonstrate large scale optical waveguide grating antennas with uniform emission operating from 1450nm to 1650nm. By tuning the laser wavelength, the beam steering angle of 30° was achieved.

Authors:Hongjie Wang, The Chinese University of Hong Kong (CUHK), Shenzhen / Caiming Sun, The Chinese University of Hong Kong (CUHK), Shenzhen / binghui li, The Chinese University of Hong Kong (CUHK), Shenzhen / Lesi Yang, Shenzhen Institute of Artificial Intelligence and Robotics for Society / Xiaomin Nie, Peng Cheng Laboratory / Aidong Zhang, Shenzhen Institute of Artificial Intelligence and Robotics for Society

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W1E

Optical Networks for Data Center and Edge

Presider: Reza Nejabati

W1E.1

Fast Edge-to-Edge Serverless Migration in 5G Programmable Packet-Optical Networks

Presenter: Istvan Pelle , *MTA-BME Network Softwarization Research Group*

Ultra-low latency serverless applications are dynamically deployed and migrated between edge computing nodes in less than 10 ms, leveraging comprehensive telemetry data retrieved from programmable packet-optical 5G x-haul.

Authors:Istvan Pelle, MTA-BME Network Softwarization Research Group / Francesco Paolucci, CNIT / Balazs Sonkoly, MTA-BME Network Softwarization Research Group / Filippo Cugini, CNIT

W1E.2

Fast and Uniform Optically-Switched Data Centre Networks Enabled by Amplitude Caching

Presenter: Thomas Gerard , *University College London*

We propose amplitude caching to optically equalise burst mode traffic without delay stages. Through a fast, optically-switched system prototype, we demonstrate burst-mode penalties can be mitigated to within 0.4 dB at the KR4 HD-FEC level.

Authors:Thomas Gerard, University College London / Kari Clark, University College London / Adam Funnell, University of Sheffield / Kai Shi, Microsoft Research / Benn Thomsen, Microsoft Research / Philip Watts, University College London / Krzysztof Jozwik, Microsoft Research / Istvan Haller, Microsoft Research / Hugh Williams, Microsoft Research / Paolo Costa, Microsoft Research / Hitesh Ballani, Microsoft Research

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W1E.3

Acceleration and Efficiency Warranty for Distributed Machine Learning Jobs Over Data Center Network With Optical Circuit Switching

Presenter: Cen Wang , *KDDI Research Inc.*

Based on a DCN with OCS, we propose a pattern-aware scheduling and fast convergence strategy for the distributed machine learning jobs. Experimental results show significant accelerations for completion time and convergence of the jobs.

Authors:Cen Wang, KDDI Research Inc. / Noboru Yoshikane, KDDI Research Inc. / Filippos Balasis, KDDI Research Inc. / Takehiro Tsuritani, KDDI Research Inc.

W1E.4

Traffic Rate Matrix Decomposition Based Conflict Free Scheduling for a Fast Optical Switching Network

Presenter: Fulong Yan , *Alibaba Cloud*

We propose a traffic rate matrix decomposition (TRMD) based conflict-free scheduling for a fast optical switching network and show that TRMD outperforms a flow control protocol with <10μs latency and >92% throughput at load of 1.

Authors:Fulong Yan, Alibaba Cloud / Chongjin Xie, Alibaba Cloud / Nicola Calabretta, Technology University of Eindhoven

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W1E.5

The Next Generation of Data Center Optical Networks Driven by Artificial Intelligence ML Applications

Invited

Presenter: Katharine Schmidtke , *Facebook Inc.*

Data Center optical networks continue to penetrate into the compute fabric where electrical interfaces struggle to keep pace with increasing bandwidth interconnect requirements driven by growth of AI Training and Inference applications.

Authors:Katharine Schmidtke, Facebook Inc.

W1F

Network Design and Operation

Presider: Hidenori Takahashi

W1F.1

Attention Mechanism-Driven Potential Fault Cause Identification in Optical Networks

Presenter: Chunyu Zhang , *Beijing University of Posts and Telecommunications*

A potential fault cause identification scheme is proposed by using attention mechanism with actual datasets, which finds out the potential fault causes for two types of optical equipment by calculating the attention weight.

Authors:Chunyu Zhang, Beijing University of Posts and Telecommunications / Danshi Wang, Beijing University of Posts and Telecommunications / Jinwei Jia, Beijing University of Posts and Telecommunications / Lingling Wang, Beijing University of Posts and Telecommunications / Songlin Liu, Beijing University of Posts and Telecommunications / Luyao Guan, Beijing University of Posts and Telecommunications / Min Zhang, Beijing University of Posts and Telecommunications

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W1F.2

Reliable Provisioning for Dynamic Content Requests in Optical Metro Networks

Presenter: Giap Le , *Department of Computer Science, UC Davis*

We investigate new methods for reliable provisioning of dynamic content requests in optical metro networks. Our methods leverage content replication across multiple edge datacenters and multipath routing.

Authors:Giap Le, Department of Computer Science, UC Davis / Sifat Ferdousi, Department of Computer Science, UC Davis / Andrea Marotta, University of L'Aquila / Sugang Xu, NICT / Yusuke Hirota, NICT / Yoshinari Awaji, NICT / Massimo Tornatore, Department of Computer Science, UC Davis / Biswanath Mukherjee, Department of Computer Science, UC Davis

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W1F.3

Power-Saving Aware Optical Path Assignment for Over-Peta-bit-Throughput SDM Photonic Node

Presenter: Fumikazu Inuzuka , *NTT Network Innovation Laboratories*

We propose a novel optical path assignment algorithm that reduces the power consumption of MC-EDFAs in SDM photonic nodes. We simulate efficient path assignment and experimentally demonstrate its power-saving relative to the conventional algorithm.

Authors:Fumikazu Inuzuka, NTT Network Innovation Laboratories / Toshifumi Nakamura, NEC System Platform Research Laboratories / Hidemi Noguchi, NEC System Platform Research Laboratories / Shigeyuki Yanagimachi, NEC System Platform Research Laboratories / Takafumi Tanaka, NTT Network Innovation Laboratories / Yutaka Miyamoto, NTT Network Innovation Laboratories

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W1F.4

Resource-Efficient Slicing With Topology-Level Protection in Optical Access/Aggregation Networks for 5G and Beyond

Presenter: Yuming Xiao , *Beijing Univ of Posts & Telecom*

We propose a topology-level protection scheme (TLPS) tailored to differential reliability demands for 5G/B5G network slicing. The cases of reliable slicing are numerically evaluated that TLPS shows its superiority in redundancy resources saving.

Authors:Yuming Xiao, Beijing Univ of Posts & Telecom / Jiawei Zhang, Beijing Univ of Posts & Telecom / Yuefeng Ji, Beijing Univ of Posts & Telecom

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W1F.5

Enabling Dynamic all Optical IP off-Loading at Tb/s Rates in Large Metro Networks

Presenter: José Alberto Hernández Gutiérrez , *Universidad Carlos III de Madrid*

Simulation experiments prove the suitability of VCSEL-based S-BVTs to enable IP off-loading in large MAN topologies. Multi-Tb/s capacity is demonstrated in a real MAN for all primary and secondary multi-level direct paths.

Authors:José Alberto Hernández Gutiérrez, Universidad Carlos III de Madrid / Mariangela Rapisarda, Politecnico di Milano / Alberto Gatto, Politecnico di Milano / Paola Parolari, Politecnico di Milano / Michela Svaluto Moreolo, CTTC/CERCA / Josep Maria Fabrega, CTTC/CERCA / Laia Nadal, CTTC/CERCA / Ricardo Martínez, CTTC/CERCA / Victor López, Telefonica I+D / Juan-Pedro Fernández-Palacios, Telefonica I+D / Pierpaolo Boffi, Politecnico di Milano / Gabriel Otero, Universidad Carlos III de Madrid / David Larrabeiti, Universidad Carlos III de Madrid

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W1F.6

Deploying Ultra-Low Loss Fibers for Enhancing Lightpath Provisioning Performance in an Elastic Optical Network

Presenter: Hao Yang , *Soochow University*

We consider network link upgrade with ultra-low loss (ULL) fibers in elastic optical backbone networks. Results demonstrate that the strategy which scans all links for ULL fiber deployment provides the best performance.

Authors:Hao Yang, Soochow University / yongcheng Li, Soochow University / Ningning Guo, Soochow University / Gangxiang Shen, Soochow University / Biswanath Mukherjee, Soochow University

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W1F.7

C to C+L Bands Upgrade With Resource Re-Provisioning in Optical Backbone Networks

Presenter: Tanjila Ahmed , *University of California Davis*

Resource re-provisioning during network upgrade from C to C+L bands can optimize resource allocation and postpone upgrade cost. Results show re-provisioning shorter lightpaths to L band leads to a more cost-effective upgrade.

Authors:Tanjila Ahmed, University of California Davis / Sabidur Rahman, University of California Davis / Aniket Pradhan, Indraprastha Institute of Information Technology / Abhijit Mitra, Indraprastha Institute of Information Technology / Massimo Tornatore, Politecnico di Milano / Andrew Lord, British Telecom / Biswanath Mukherjee, University of California Davis

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W1F.8

Optical Power Control Strategies for Optimized C+L+S-Bands Network Performance

Presenter: Bruno Araujo Correia , *Politecnico di Torino*

This work describes and assesses the performance of a meta-heuristic algorithm applied for launch power control in multi-band (C+L+S) optical networks.

Authors:Bruno Araujo Correia, Politecnico di Torino / Raoul Sadeghi Yamchi, Politecnico di Torino / Emanuele Virgillito, Politecnico di Torino / Antonio Napoli, Infinera / Nelson Costa, Infinera Unipessoal Lda / João Pedro, Infinera Unipessoal Lda / Vittorio Curri, Politecnico di Torino

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W1G
Disaggregated and Multilayer Optical Networks

Presider: Achim Autenrieth

W1G.1

Telemetry Solutions in Disaggregated Optical Networks: an Experimental View

Invited

Presenter: Francesco Paolucci , *CNIT*

Effective telemetry streaming for disaggregated whitebox is discussed, focusing on implementation issues. A novel gRPC peer-to-peer telemetry for next-generation AI-equipped xPonders is proposed and evaluated in a disaggregated testbed exploiting OpenConfig and OpenROADM models.

Authors:Francesco Paolucci, CNIT / Andrea Sgambelluri, Scuola Superiore Sant Anna di Pisa / Piero Castoldi, Scuola Superiore Sant Anna di Pisa / Filippo Cugini, CNIT

W1G.2

GNPy Experimental Validation on Flex-Grid, Flex-Rate WDM Optical Transport Scenarios

Presenter: Andrea D'Amico , *Politecnico di Torino*

We demonstrate accurate GSNR predictions for a flex-grid and flex-rate experimental transmission using an enhanced implementation of the open-source GNPy library for a 1600\,km OLS, involving QPSK, 8-QAM and 16-QAM modulation formats.

Authors:Andrea D'Amico, Politecnico di Torino / Elliot London, Politecnico di Torino / Bertrand Le Guyader, Orange Labs / Florian Frank, Orange Labs / Esther Le Rouzic, Orange Labs / Erwan Pincemin, Orange Labs / Nicolas Brochier, Orange Labs / Vittorio Curri, Politecnico di Torino

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W1G.3

Coordinating Pluggable Transceiver Control in SONiC-Based Disaggregated Packet-Optical Networks

Presenter: Filippo Cugini , *CNIT*

Effective control of pluggable transceivers in SONiC-based packet-optical nodes is demonstrated. A workflow for multi-layer recovery upon soft failure detection is validated, showing no traffic disruption and fast node-driven coordination between packet and optical operations.

Authors:Andrea Sgambelluri, Scuola Superiore Sant Anna di Pisa / Davide Scano, Scuola Superiore Sant Anna di Pisa / Alessio Giorgetti, IEIIT-CNR / Francesco Paolucci, CNIT / Piero Castoldi, Scuola Superiore Sant Anna di Pisa / Emilio Riccardi, TIM / Roberto Morro, TIM / Filippo Cugini, CNIT

W1G.4

Delay-Aware and Resource-Efficient VNF-Service Chain Deployment in Inter-Datacenter Elastic Optical Networks

Presenter: Jiahua Gu , *Southeast University*

We propose an integer linear programming (ILP) model and a heuristic algorithm for resource-efficient virtual network function (VNF) deployment in inter-datacenter elastic optical networks that optimize both the computing resource usage and the VNF processing delay.

Authors:Jiahua Gu, Southeast University / Min Zhu, Southeast University / Tianyu Shen, Southeast University / Chenglin Shi, Southeast University / Xueqi Ren, Southeast University

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W1G.5

Multi-Layer Transport Network Slicing With Hard and Soft Isolation

Presenter: Ricard Vilalta , *CTTC*

We validate the deployment of isolated transport network slices in IP over DWDM network. To this end, an isolated transport network slice is deployed using multi-layer isolation mechanisms based on OpenConfig and ONF Transport API.

Authors:Alejandro Alcalá, Universidad Autónoma de Madrid / Samier Barguil, Universidad Autónoma de Madrid / Victor López, Telefónica I+D / Luis Miguel Contreras, Telefónica I+D / Carlos Manso, CTTC / Pol Alemany, CTTC / Ramon Casellas, CTTC / Ricardo Martínez, CTTC / David González-Pérez, Volta Networks / Xufeng Liu, Volta Networks / José Miguel Pulido, Volta Networks / Juan-Pedro Fernández-Palacios, Telefónica I+D / Raul Muñoz, CTTC / Ricard Vilalta, CTTC

W1G.6

(Withdrawn) Multi-Layer Hierarchical Control: Use Cases, Standards and Evolution

Invited

Presenter: Ori Gerstel , *Sedona Systems*

The three-tier SDN control hierarchy for multilayer networks has solidified on multiple fronts: key operator groups endorsed it, standards are solidifying, common SP use cases are defined; and products for all three tiers are available.

Authors:Ori Gerstel, Sedona Systems

W1H

Cost-effective PON

Presider: Marco Ruffini

W1H.1

Assessment of an SOA for Burst Mode Pre-Amplification in Higher Speed PON Reaching 30dB of Optical Budget

Presenter: Jeremy Potet , *Orange*

We perform 30dB optical budget burst mode transmission at 25Gbit/s with an EML and a DC-30GHz PIN pre-amplified with an SOA. We demonstrate that the SOA does not deteriorate the quality of the transmission.

Authors:Jeremy Potet, Orange / Fabienne Saliou, Orange / Gael Simon, Orange / Mathilde Gay, Institut Foton / Laurent Bramerie, Institut Foton / Philippe Chanclou, Orange / Monique Thual, Institut Foton

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W1H.2

32dB of Optical Budget With DSP-Free Real Time Experimentation up to 50Gbit/s NRZ Using O-Band DFB-EAM and SOA-PIN for Higher Speed PONs

Presenter: Fabienne SALIOU , *Orange*

We achieve 32.3dB of optical budget and 45km reach transmission in real time with an O-band EAM-DFB and SOA-PIN for 50Gbit/s NRZ standards. A DSP-free transmission was demonstrated with a semi-cooled transmitter

Authors:Fabienne SALIOU, Orange / Mathilde Gay, Almae Technologies / Laurent Bramerie, Université Rennes 1, CNRS, Institut Foton / Jeremy Potet, Orange / Hamza Hallak Elwan, Orange / Gael Simon, Orange / Philippe Chanclou, Orange / Francois Lelarge, Almae Technologies / Hélène Debrégeas, Almae Technologies

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W1H.3

The Best Modulation Format for Symmetrical Single-Wavelength 50-Gb/s PON at O-Band: PAM, CAP or DMT?

Presenter: Jiao Zhang , *Southeast University*

We experimentally demonstrated and compared PAM-4, CAP-16QAM and DMT-16QAM modulations in a symmetrical 50-Gb/s/λ PON based on bandwidth-limited optics over the same fiber link at O-band. The performance of power budget and dispersion are discussed.

Authors:Jiao Zhang, Southeast University / Min Zhu, Southeast University / Kaihui Wang, Fudan University / Qingyi Zhou, Southeast University / Bingchang Hua, Southeast University / Yuancheng Cai, Southeast University / Mingzheng Lei, Southeast University / Yucong Zou, Southeast University / Aijie Li, Southeast University / Weiliang Xu, Southeast University / Jikuan Wang, Southeast University / Xiang Liu, Southeast University / Jianjun Yu, Purple Mountain Laboratories

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W1H.4

Up to 20 Mb/s Auxiliary Management and Control Channel Signal Transmission in 50 Gb/s PON System

Presenter: Haipeng Guo , *Peking University*

Up to 20 Mb/s transmission of AMCC signal with different modulation formats over 50 Gb/s PAM4 PON is experimentally demonstrated. The results confirm power penalty for PON signal in AMCC superimposition is lower than 1dB.

Authors:Haipeng Guo, Peking University / Chuanchuan Yang, Peking University / Xin Qin, Peking University / Yunfeng Gao, Peking University / Ziyuan Zheng, Peking University / Hongbin Li, Peking University

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W1I

Real-time and High-data Rate Transmission

Presider: Werner Klaus

W1I.1

Real-Time Unrepeatered C-Band Transmission of 30.5 Tb/s Over 276.4 km and 29.45 Tb/s Over 292.5 km

Presenter: Hans Bissessur , *Alcatel Submarine Networks*

We present record unrepeatered experiments with 61 real-time 32-QAM channels at 500 Gb/s over 276.4 km, or with hybrid 16/32 QAM modulation over 292.5 km, applying a high-power booster and third-order Raman amplification

Authors:Hans Bissessur, Alcatel Submarine Networks / Christian Bastide, Alcatel Submarine Networks / Alexis Busson, Alcatel Submarine Networks / Daryna Kravchenko, Alcatel Submarine Networks / Farana Hedaraly, Alcatel Submarine Networks / juan esparza, Alcatel Submarine Networks

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W1I.2

16-Tb/s Real-Time Demonstration of 100-km MDM Transmission Using Commercial 200G OTN System

Presenter: Lei Shen , *YOFC*

A real-time 2-LP-mode × 40 wavelength × 200-Gb/s DP-16QAM MDM transmission with total 16-Tb/s capacity over 100-km long weakly-coupled DRC-FMF based on commercial real-time 200G OTN system is successfully demonstrated for the first time.

Authors:Lei Shen, YOFC / Dawei Ge, Peking University / Shikui Shen, China Unicom / Shuo Wang, China Unicom / Chunxu Zhao, China Unicom / Guangquan Wang, China Unicom / Lei Zhang, YOFC / Jie Luo, YOFC / Xiaobo Lan, YOFC / Lan Deng, YOFC / Mingqing Zuo, Peking University / Yuyang Gao, Peking University / Juhao Li, Peking University

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W1I.3

10,000 km Straight-Line Transmission Using a Real-Time Software-Defined GPU-Based Receiver

Presenter: Sjoerd van der Heide , *National Institute of Information and Communication Technology (NICT)*

Real-time operation of a software-defined, GPU-based optical receiver is demonstrated over a 100-span straight-line optical link. Performance of minimum-phase Kramers-Kronig 4-, 8-, 16-, 32-, and 64-QAM signals are evaluated at various distances.

Authors:Sjoerd van der Heide, National Institute of Information and Communication Technology (NICT) / Ruben Luis, National Institute of Information and Communication Technology (NICT) / Benjamin Puttnam, National Institute of Information and Communication Technology (NICT) / Georg Rademacher, National Institute of Information and Communication Technology (NICT) / A.M.J. Koonen, Eindhoven University of Technology / Satoshi Shinada, National Institute of Information and Communication Technology (NICT) / Yoshinari Awaji, National Institute of Information and Communication Technology (NICT) / Hideaki Furukawa, National Institute of Information and Communication Technology (NICT) / Chigo Okonkwo, Eindhoven University of Technology

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W1I.4

Demonstration of 800-Gbit/s/Carrier TPS-64QAM WDM Transmission Over 2,000 km Using MIMO Volterra Equalization

Presenter: Miao Kong , *Fudan University*

We experimentally demonstrated a 125-GHz-grid WDM coherent transmission over 2,000-km Raman amplified ULAF with 800-Gbit/s/carrier net-bit-rate based on 100-Gbaud truncated PS-64QAM. Our results show that the MIMO-VNLE outperforms the SISO-VNLE by around 67% reach improvement.

Authors:Miao Kong, Fudan University / Cuiwei Liu, Fudan University / Bohan Sang, Fudan University / Kaihui Wang, Fudan University / Junjie Ding, Fudan University / Junting Shi, Fudan University / Li Zhao, Fudan University / Wen Zhou, Fudan University / Xiangjun Xin, Beijing University of Posts and Telecommunications / Bo Liu, Beijing University of Posts and Telecommunications / Bing Ye, ZTE Corp. / Weizhang Chen, ZTE Corp. / Jianjun Yu, Fudan University

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W1I.5

High Spectrum Efficiency and High Capacity Transmission for 800Gbps and Beyond

Invited

Presenter: Asuka Matsushita , *NTT Corporation*

High throughput signals with high spectral efficiency are attracting interest for their application to data center interconnection application. This paper describes steps in designing a high SE signal with a net rate of beyond 800-Gbps/λ.

Authors:Asuka Matsushita, NTT Corporation

W1J

Radio-over-fiber (RoF) Systems

Presider: Morio Toyoshima

W1J.1

Over 100Gb/s PS-4096 QAM Signal Bi-Directional Transmission in a Full-Duplex MMW-RoF System at E-Band

Presenter: KAIHUI WANG , *Fudan University*

We experimentally demonstrate a bidirectional photonics-aided MMW transmission system at E-band (71-76 GHz and 81-86 GHz). The proposed full-duplex MMW-RoF system can support 7 GBaud PS-4096 QAM signal transmission over 2-m wireless link when satisfying the SD-FEC threshold at 4.2×10^{-2}.

Authors:KAIHUI WANG, Fudan University / Li Zhao, Fudan University / Wen Zhou, Fudan University / Cuiwei Liu, Fudan University / Yanyi Wang, Fudan University / Feng Zhao, Xian University of Posts and Telecommunications / Jianjun Yu, Fudan University

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W1J.2

Simplified Coherent Receiver for Zero-Touch Wireless Integration in Power-Splitting ODN With >40 dB Budget

Presenter: Dinka Milovancev , *AIT Austrian Institute of Technology*

We experimentally demonstrate radio-over-fiber transmission over an optical budget of 42dB, using an ultra-low complexity, DSP-free coherent EML+TIA receiver. Its sensitivity enables the wireless integration in filterless, power-splitting wireline networks with budgets beyond NG-PON2 class-E2.

Authors:Dinka Milovancev, AIT Austrian Institute of Technology / Nemanja Vokic, AIT Austrian Institute of Technology / Fotini Karinou, Microsoft Research Ltd. / Bernhard Schrenk, AIT Austrian Institute of Technology

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W1J.3

Orthogonal Chirp-Division Multiplexing for Performance Enhanced Optical/Millimeter-Wave 5G/6G Communications

Presenter: Colm Browning , *Dublin City University*

Orthogonal chirp-division multiplexing is deployed as a novel waveform in an optical/millimeter-wave system. Enhanced channel estimation gives a 5-dB receiver sensitivity improvement over a conventional OFDM implementation, and compatibility with 256-QAM at 60-GHz is experimentally demonstrated.

Authors:Colm Browning, Dublin City University / Xing Ouyang, Tyndall National Institute / Devika Dass, Dublin City University / Giuseppe Talli, Tyndall National Institute / Paul Townsend, Tyndall National Institute

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W1J.4

Demonstration of 28-GHz Band Radio Signal Transmission Into Vehicle by Analog Radio Over Multi-Mode Fiber

Presenter: Hiroki Yasuda , *Yazaki corporation*

We demonstrate transmitting 28-GHz band radio signals from cascaded IFoF based C-RAN mobile fronthaul system to inside a vehicle by re-radiation of the cost-effective analog radio over multi-mode fiber employing a directly modulated VCSEL.

Authors:Hiroki Yasuda, Yazaki corporation / Toshinori Suzuki, Yazaki corporation / Hsuan Kao, KDDI research, Inc. / Satoshi Tanaka, Yazaki corporation / Shota Ishimura, KDDI research, Inc. / Kazuki Tanaka, KDDI research, Inc. / Naokatsu Yamamoto, National Institute of Information and Communications Technlogy / Atsushi Kanno, National Institute of Information and Communications Technlogy / Ryo Inohara, KDDI research, Inc. / Kosuke Nishimura, KDDI research, Inc. / Takamitsu Aiba, Yazaki corporation / Tomohiro Wakabayashi, Yazaki corporation / Tetsuya Kawanishi, Waseda University

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W1J.5

A Quantum-Dash Dual-Wavelength DFB Laser for Optical Millimeter-Wave Radio-Over-Fiber Systems

Presenter: Khan Zeb , *National Research Council Canada*

We experimentally demonstrate an optical-heterodyne millimeter-wave radio-over-fiber system with broadband wireless links through 25.22 km standard-single-mode fiber featuring a high bitrate of 24-Gb/s (64QAM × 4GBaud) using a highly correlated InAs/InP quantum-dash dual-wavelength DFB laser.

Authors:Khan Zeb, National Research Council Canada / Zhenguo Lu, National Research Council Canada / Jiaren Liu, National Research Council Canada / Youxin Mao, National Research Council Canada / Mohamed Rahim, National Research Council Canada / Philip Poole, National Research Council Canada / Pedro Barrios, National Research Council Canada / Guocheng Liu, National Research Council Canada / Grzegorz Pakulski, National Research Council Canada / Weihong Jiang, National Research Council Canada / Martin Vachon, National Research Council Canada / Daniel Poitras, National Research Council Canada / Xiupu Zhang, Concordia University

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W1J.6

4×10 Gb/s WDM Fiber Wireless Multi-IFoF Reconfigurable Fronthaul Using a low-Loss Si_3N_4 ROADM for MmWave 5G

Presenter: Eugenio Ruggeri , *Aristotle University of Thessaloniki*

Four 10 Gb/s multi-IFoF 16-QAM WDM Fiber-Wireless links are transmitted through 10km fiber and 50cm directional V-band antennas and flexibly reconfigured by a Si_3N_4 ROADM, towards record 40 Gb/s wavelength-routed fronthaul capacity for mmWave 5G

Authors:Eugenio Ruggeri, Aristotle University of Thessaloniki / Dimosthenis Spasopoulos, Aristotle University of Thessaloniki / Christos Vagionas, Aristotle University of Thessaloniki / George Kalfas, Aristotle University of Thessaloniki / Ruud Oldenbeuving, LIONIX International B.V. / Paul Van Dijk, LIONIX International B.V. / Chris Roeloffzen, LIONIX International B.V. / Nikos Pleros, Aristotle University of Thessaloniki / Amalia Miliou, Aristotle University of Thessaloniki

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5:00 - 5:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC13

Exhibit Hall Event - Technology Showcase: Differential AC Coupling For Ultra Broadband Signal Lines : The Ideal Solution Up to 220GHz !

5:00 - 6:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

5:30 - 6:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC14

Exhibit Hall Event - Technology Showcase: Silicon Photonic Integrated Chip Results Using AIM Photonics

6:00 - 8:00 Pacific Time (US & Canada) (UTC - 07:00)

W2A

Rump Session: Did the Optics Industry Blunder by Switching Intra-Datacenter Links from NRZ to PAM4? Will More DSP like PAM6 and Coherent Follow, or Will WDM and Parallel Save the Day?

7:30 - 8:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE3

Exhibit Hall Event - OFC Career Zone: The Benefits of Research with Dr. Mason

8:00 - 10:00 Pacific Time (US & Canada) (UTC - 07:00)

W3A

Special Event - Special Session: Lessons Learned: Networks 2020 Status and Next Steps

Moderator: Stephen Grubb

W3A.1

The Internet is now an ESSENTIAL Service

Invited

Presenter: Najam Ahmad , *Facebook Inc.*

Abstract not available.

Authors:Najam Ahmad, Facebook Inc.

W3A.2

Selected Learnings From a Global Pandemic

Invited

Presenter: Kevin Dean , *EuNetworks*

Abstract not available.

Authors:Kevin Dean, EuNetworks

W3A.3

Google Perspective on 2020 Network Trends

Invited

Presenter: Vijay Vusirikala , *Google LLC*

Abstract not available.

Authors:Vijay Vusirikala, Google LLC

W3A.4
Network 2020 Status and Next Steps: Global View of Internet Traffic Over the Last 16 Months
Invited

Presenter: Craig Labovitz , *Nokia Deepfield*

Abstract not available.

Authors:Craig Labovitz, Nokia Deepfield

W3A.5
2020 – Lessons Learned
Invited

Presenter: Glenn Wellbrock , *Verizon Communications Inc*

Abstract not available.

Authors:Glenn Wellbrock, Verizon Communications Inc

10:00 - 10:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC15

Exhibit Hall Event - Technology Showcase: Addressing Mixed-Signal Requirements for High-Performance Optical Communications

10:00 - 11:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

10:15 - 10:45 Pacific Time (US & Canada) (UTC - 07:00)

NOSK

Exhibit Hall Event - Network Operator Summit Keynote: Neil McRae

10:30 - 11:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC16

Exhibit Hall Event - Technology Showcase: Optical Engines Evolution -- 100Gbaud and Beyond

11:00 - 11:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE13

Exhibit Hall Event - OSA Booth, Tech Talk: LIDAR, Boom or Bust?

11:00 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

NOS1

Exhibit Hall Event - Network Operator Summit: Reality Check for 5G Networks: Network Operator Perspective

11:00 - 13:00 Pacific Time (US & Canada) (UTC - 07:00)

W4A

Symposia: The Role of Machine Learning in Optical Systems and the Role of Optics in Machine Learning Systems (Part 1)

Presider: Manya Ghobadi

W4A.1

Applied Machine Learning in Facebook Data Centers

Invited

Presenter: Katharine Schmidtke , *Facebook*

The latest datacenter workloads in machine learning are growing rapidly and are challenging current electrical interconnect technology in terms of bandwidth and reach. Optics look like a promising solution for the next generation.

Authors:Katharine Schmidtke, Facebook

W4A.2
Machine Learning Workloads and TPUs in Data Centers
Invited

Presenter: Norman Jouppi , *Google*

Abstract not available.

Authors:Norman Jouppi, Google

W4A.3
The Role of Photonic Switching for Machine Learning Workloads in Data Centers
Invited

Presenter: Hitesh Ballani , *Microsoft Research Ltd*

Abstract not available.

Authors:Hitesh Ballani, Microsoft Research Ltd

W4A.4
Machine-Learning-Aided Bandwidth and Topology Reconfiguration for Optical Data Center Networks
Invited

Presenter: Roberto Proietti , *University of California, Davis*

We present an overview of the application of machine learning for traffic engineering and network optimization in optical data center networks. In particular, we discuss the application of supervised and unsupervised learning for bandwidth and topology reconfiguration.

Authors:Roberto Proietti, University of California, Davis / Che-Yu Liu, University of California, Davis / Xiaoliang Chen, University of California, Davis / S. J. Ben Yoo, University of California, Davis

12:00 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE14
Exhibit Hall Event - OSA Booth, Tech Talk: Silicon Photonic Circuit Design

13:30 - 14:30 Pacific Time (US & Canada) (UTC - 07:00)

SF7

Exhibit Hall Event - Industry Program: Next Generation Optical Interfaces -- An IEEE and Industry Update

SF8

Exhibit Hall Event - Industry Program: Open Eye MSA: Road to Low Cost PAM-4 Optics

13:30 - 15:00 Pacific Time (US & Canada) (UTC - 07:00)

NOS2

Exhibit Hall Event - Network Operator Summit: Less Hyper Scale and More Co-location and Compute at the edge?

13:30 - 15:30 Pacific Time (US & Canada) (UTC - 07:00)

W5A

Symposia: The Role of Machine Learning in Optical Systems and the Role of Optics in Machine Learning Systems (Part 2)

Presider: Manya Ghobadi

W5A.1

What Photonics can do in GPU Based Machine Learning Systems

Invited

Presenter: Larry Dennison , *NVIDIA Corporation*

Abstract not available.

Authors:Larry Dennison, NVIDIA Corporation

W5A.2

Programmable Photonics for Optical Accelerators

Invited

Presenter: Dirk Englund , *Massachusetts Institute of Technology*

Abstract not available.

Authors:Dirk Englund, Massachusetts Institute of Technology

W5A.3
Photonic Integrated Circuits for Neural Network Inference and Training
Invited

Presenter: Bert Offrein , *IBM Research GmbH*

Abstract not available.

Authors:Bert Offrein, IBM Research GmbH

W5A.4
Optical and Electrical Computing Energy Use Comparison
Invited

Presenter: Christopher Cole , *II-VI Incorporated*

Abstract not available.

Authors:Christopher Cole, II-VI Incorporated

15:00 - 15:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE15
Exhibit Hall Event - OSA Booth, Tech Talk: How I Use Python to Automate My Experiments

15:30 - 16:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC17
Exhibit Hall Event - Technology Showcase: Monolithic Silicon Photonics: Innovative Solutions for Co-packaged Optical Switches

15:30 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor

news

MW4

Exhibit Hall Event - Market Watch: Evolution to Coherent WDM Integration in Routers

16:00 - 16:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC18

Exhibit Hall Event - Technology Showcase: Recent Advancements in Photonic Test and Packaging Automation

17:00 - 18:30 Pacific Time (US & Canada) (UTC - 07:00)

SF10

Exhibit Hall Event - Industry Program: Why Ethernet? Why Now?

SF9

Exhibit Hall Event - Industry Program: The Disaggregated Optical & Transport Network

17:00 - 19:00 Pacific Time (US & Canada) (UTC - 07:00)

W6A

Joint Poster Session 1

W6A.1

Towards Fully Automated Testing and Characterization for Photonic Compact Modeling on 300-mm Wafer Platform

Presenter: Abdelsalam Aboketaf , *Globalfoundries*

We demonstrate a fully automated and flexible wafer-level photonic device testing and characterization with wavelength, optical power, temperature, and voltage dependencies. High precision setup and data analysis tools are developed for photonic compact modeling.

Authors:Abdelsalam Aboketaf, Globalfoundries / Crystal Hedges, Globalfoundries / Vishal Dhurgude, Globalfoundries / Brendan Harris, Globalfoundries / Fen Guan, Globalfoundries / Frank Pavlik, Globalfoundries / Ted Anderson, Globalfoundries / Andy Stricker, Globalfoundries / Yusheng Bian, Globalfoundries / Michal Rakowski, Globalfoundries / Arunima Dasgupta, Globalfoundries / Andrea Paganini, Globalfoundries

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W6A.10

An Ultra-Broadband Two-Mode Transverse-Electric Multiplexer in SOI Platform

Presenter: Bruna Paredes , *New York University-Abu Dhabi*

We report an ultra-broadband two-mode (de) multiplexer using a tapered asymmetric directional coupler (ADC). Measurements exhibit insertion loss less than 1.2 dB and crosstalk better than 16 dB covering 1260-1360 nm and 1500-1600 nm.

Authors:Bruna Paredes, New York University-Abu Dhabi / Zakriya Mohammed, New York University-Tandon School of Engineering / Juan Villegas, New York University-Tandon School of Engineering / Mahmoud Rasras, New York University-Abu Dhabi

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W6A.11

High-Precision Edge-Cloud Collaboration With Federated Learning in Edge Optical Network

Presenter: Chao Li , *Beijing University of Posts and Telecomm*

This paper proposes a high-precision edge-cloud collaborative federated learning (ECFL) scheme based on data matching in Metro Optical Network. ECFL improves the training accuracy of machine learning and reduces the network-blocking rate.

Authors:Chao Li, Beijing University of Posts and Telecomm / Hui Yang, Beijing University of Posts and Telecomm / Qiuyan Yao, Beijing University of Posts and Telecomm / Zhengjie Sun, Beijing University of Posts and Telecomm / Jie Zhang, Beijing University of Posts and Telecomm

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W6A.12

Enabling Transmission-Aware Adaptive Optical Time Slice Switching in Time-Varying Optical Time Sliced Networks

Presenter: Chen Zhao , *Beijing National Research Center for Information Science and Technology (Abbreviation: BNRist)*

An adaptive all-optical time slice switching method based on optical signal envelope perception is studied. Results show high resource utilization can be achieved with fine switching granularity in extreme satellite optical network scenarios.

Authors:Chen Zhao, Beijing National Research Center for Information Science and Technology (Abbreviation: BNRist) / Nan Hua, Beijing National Research Center for Information Science and Technology (Abbreviation: BNRist) / Kangqi Zhu, Beijing National Research Center for Information Science and Technology (Abbreviation: BNRist) / Jipu Li, Beijing National Research Center for Information Science and Technology (Abbreviation: BNRist) / Bofan Yang, Beijing National Research Center for Information Science and Technology (Abbreviation: BNRist) / Xiaoping Zheng, Beijing National Research Center for Information Science and Technology (Abbreviation: BNRist)

W6A.13

Joint Multi-Eigenvalue Demodulation Using Complex Moment-Based Eigenvalue Solver and Artificial Neural Network

Presenter: Yuhei Terashi , *Osaka University*

We demonstrate a joint demodulation scheme using a parallel eigenvalue solver and ANN. The proposed scheme is demonstrated experimentally by 2000-km fiber transmission with <2-dB OSNR penalty compared with conventional QZ method.

Authors:Yuhei Terashi, Osaka University / Daisuke Hisano, Osaka University / Ken Mishina, Osaka University / Yuki Yoshida, National Institute of Information and Communications Technology / Akihiro Maruta, Osaka University

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W6A.14

Universal Virtual Lab: a Fast and Accurate Simulation Method for Nonlinear DWDM Systems

Presenter: David Dahan , *Toga Networks - a Huawei company*

We present a fast, accurate and highly parallel-processed simulation method for BER assessments of nonlinear DWDM systems based on the time-varying NLIN model with estimation errors below 0.1dBQ and speedup factors reaching over one thousand.

Authors:David Dahan, Toga Networks - a Huawei company / Michael Zarubinsky, Toga Networks - a Huawei company / Yunhua Liang, Toga Networks - a Huawei company / Ori Golani, Tel Aviv University / Mark Shtaif, Tel Aviv University

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W6A.15

Field Trial of Semi-Active WDM System Based on Multi-Carrier Pilot-Tone for 5G C-RAN Front-Haul Network

Presenter: Dong Wang , *China Mobile Research Institute*

Semi-active WDM system based on multi-carrier pilot-tone with on-line management is proposed. Error-free real-time 24-hour filed-trial transmission of 12-channel 25-Gbps eCPRI signals combined with 12-carrier 512-bps pilot-tone OAM signals over 10 km is demonstrated.

Authors:Dong Wang, China Mobile Research Institute / Youxi Lin, Huawei Technologies Co., Ltd. / Jiang Sun, China Mobile Research Institute / Dawei Ge, China Mobile Research Institute / Dechao Zhang, China Mobile Research Institute / Gongyuan Zhao, Huawei Technologies Co., Ltd. / Qian Cai, China Mobile Research Institute / Yunbo Li, China Mobile Research Institute / Yang Zhao, China Mobile Research Institute / Liuyan Han, China Mobile Research Institute / Enbo Zhao, Huawei Technologies Co., Ltd. / Han Li, China Mobile Research Institute

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W6A.16

Principal Axes Twist of Antiresonant Hollow-Core Fiber

Presenter: Elizaveta Yelistratova , *Bauman Moscow State Technical University*

We present measurements of antiresonant hollow-core fiber principal axes twist and orientation under different bend conditions in the spectral region of 2.26 – 2.36 μm.

Authors:Elizaveta Yelistratova, Bauman Moscow State Technical University / Stanislav O. Leonov, Bauman Moscow State Technical University / Vladimir V. Demidov, P. N. Lebedev Physical Institute of the Russian Academy of Sciences / Valeriy E. Karasik, Bauman Moscow State Technical University

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W6A.17

Benchmarking of Carrier Phase Recovery Circuits for M-QAM Coherent Systems

Presenter: Erik Börjeson , *Chalmers University of Technology*

We benchmark blind carrier phase recovery DSP circuits in terms of SNR penalty, power dissipation, latency, area usage, and cycle slip probability, to identify optimal implementations for 16, 64, and 256QAM.

Authors:Erik Börjeson, Chalmers University of Technology / Per Larsson-Edefors, Chalmers University of Technology

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W6A.18

100 GBaud SSB PAM-4 Signal Transmission Over 80-km SMF With THP and KK Receiver

Presenter: Dongdong Zou , *Sun Yat-Sen University*

We experimentally demonstrate the transmission of 100 GBaud SSB PAM-4 signal with 93.4 GSa/s AWG over 80-km SMF with BER below 20% SD-FEC threshold of 2×10^{-2}, which is enabled by THP, KK receiver and only linear FFE. The proposed scheme is a potential solution for next generation 800 GE 80-km inter-DCI.

Authors:Fan Li, Sun Yat-Sen University / Dongdong Zou, Sun Yat-Sen University

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W6A.19

Quantization Noise Suppression With Noise-Shaping Technique in DMT-Modulated IM/DD Optical Interconnects Utilizing Low-Resolution DAC

Presenter: ke bai , *Sun Yat-Sen University*

Beyond 100 Gb/s 16/32QAM DMT signal transmitting over 2-km SMF enabled by DAC with 4-bit quantization resolution in IM/DD system is experimentally demonstrated. With the noise-shaping technique, the system with 4-bit quantization presents the same performance as the conventional IM/DD system with quantization resolution of 8-bit at BER of 3.8×10^{-3}.

Authors:Fan Li, Sun Yat-Sen University / ke bai, Sun Yat-Sen University

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W6A.2

32 Tbit/s Transmission Over 1400 km Using Power Allocation Optimization

Presenter: Abel Lorences-Riesgo , *Huawei Technologies*

Transmission of C-band 40×800 Gbit/s signals using 125 Gbaud PCS-64QAM is demonstrated by performing power allocation optimization at the input of 3 OMSs along a 15-span link (>20 dB loss each) with EDFA-only amplification.

Authors:Abel Lorences-Riesgo, Huawei Technologies / Trung-Hien Nguyen, Huawei Technologies / Sami Mumtaz, Huawei Technologies / Dylan Le Gac, Huawei Technologies / Ivan Fernandez de Jauregui Ruiz, Huawei Technologies / Marti Sales Llopis, Huawei Technologies / Stefanos Dris, Huawei Technologies / Yann Frignac, Huawei Technologies / Gabriel Charlet, Huawei Technologies

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W6A.20

Experimental Demonstration of Remotely Controlled and Powered Tunable Optical 2-4 Taps Correlator of a 20-100 Gbit/s QPSK Channel Based on Laser-Delivered Bias and Control Signals

Presenter: Fatemeh Alishahi , *University of Southern California*

We experimentally demonstrate a 2-4 tap QPSK correlation using a cascade of MZIs which are remotely controlled through an optical link. The delivered power to the correlator is tuned and different target patterns are tailored.

Authors:Fatemeh Alishahi, University of Southern California / Amir Minoofar, University of Southern California / Ahmad Fallahpour, University of Southern California / Kaiheng Zou, University of Southern California / Huibin Zhou, University of Southern California / Jonathan Habif, Information Sciences Institute / Moshe Tur, Tel Aviv university / Alan Willner, University of Southern California

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W6A.21

How Large Should Be the Fiber Effective Area: a Network-Oriented Case Study?

Presenter: Ningning Guo , *Soochow University*

In elastic optical network, lightpath provisioning using spectrum-assignment schemes and optical signal-to-noise-ratio (OSNR) model show that, while lowering fiber loss is always helpful, increasing fiber effective area beyond 110 μm^2 does not improve spectrum efficiency.

Authors:Ningning Guo, Soochow University / Yichun Shen, Zhongtian Technology Fiber Optics Co., Ltd / Xinli Jiang, Zhongtian Technology Fiber Optics Co., Ltd / Shanshan Cao, Zhongtian Technology Fiber Optics Co., Ltd / Gangxiang Shen, Soochow University / Biswanath Mukherjee, Soochow University

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W6A.22

Widely Tunable Apodized Bragg Grating Filter Fabricated in a Silicon Photonic Foundry

Presenter: Gareeyasee Saha , *Georgia Institute of Technology*

Apodized Bragg grating filters offer unique advantages yet require precise fabrication tolerances. We demonstrate a CMOS foundry fabricated widely tunable filter with a sharp edge roll-off of 35dB/nm, a flat 20nm transmission band and low-loss.

Authors:Gareeyasee Saha, Georgia Institute of Technology / Stephen Ralph, Georgia Institute of Technology

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W6A.23

Structured Sparsity Learning-Based Pruned Retraining Volterra Equalization for Data-Center Interconnects

Presenter: govind sharan yadav , *National Tsing Hua University Taiwan*

We propose a structured sparsity learning-based pruned retraining Volterra equalization for inter-dadta-center interconnects. Compared with conventional VE, we achieve 95% and 90.5% complexity reduction without signal degradation for B2B and 40-km at 80-Gb/s PAM4, respectively.

Authors:govind sharan yadav, National Tsing Hua University Taiwan / Chun-Yen Chuang, National Chiao Tung University / Kai-Ming Feng, National Tsing Hua University Taiwan / Jyehong Chen, National Chiao Tung University / Young-Kai Chen, DARPA

W6A.24

Advanced Beam Shaping for Enhanced Underwater Wireless Optical Communication

Presenter: Jiewen Nie , *Southeast University*

A diffraction-based optical launching unit was demonstrated to improve the propagating efficiency of the laser beam in the lossy and scattering medium, leading to significant enhancement on the underwater transmission quality over 15m at 100Mbps.

Authors:Jiewen Nie, Southeast University / Lei Tian, Southeast University / Song Yue, Institute of Microelectronics of the Chinese Academy of Sciences / Zichen Zhang, Institute of Microelectronics of the Chinese Academy of Sciences / Haining Yang, Southeast University

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W6A.25

Demonstration of 2-Gbit/s Free-Space Optical Communications Through Dynamic Aerosol and Dynamic Water Interface Using Orbital-Angular-Momentum Multiplexing

Presenter: Haoqian Song , *University of Southern California*

We experimentally demonstrate 2-Gbit/s OAM-multiplexed free-space optical communications through dynamic aerosol and dynamic water interface. We observe a ~2-dB power penalty at the 7% FEC limit for both OAM -1 and +2 channels.

Authors:Haoqian Song, University of Southern California / Runzhou Zhang, University of Southern California / Nanzhe Hu, University of Southern California / Huibin Zhou, University of Southern California / Xinzhou Su, University of Southern California / Kaiheng Zou, University of Southern California / Kai Pang, University of Southern California / Hao Song, University of Southern California / Cong Liu, University of Southern California / Brittany Lynn, Space & Naval Warfare Systems Center / Daeyoung Park, , Inha University / Moshe Tur, Tel Aviv University / Alan Willner, University of Southern California

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W6A.26

High Radix SOA-Based Lossless Optical Switch Prototyping for 25 GBaud PAM4 Transmission in Modern Intra-Datacenter Applications

Presenter: Hassan Mojaver , *McGill University*

In a development towards high-radix datacenter networks, we demonstrate 25 GBaud PAM4 transmission through a three-stage 8 × 8 SOA-based lossless optical switch, implemented as a monolithic photonic integrated circuit in indium phosphide.

Authors:Hassan Mojaver, McGill University / Shanglin Li, McGill University / Valery Tolstikhin, Intengent, Inc. / Kin-Wai Leong, Rockport Networks, Inc. / Odile Liboiron-Ladouceur, McGill University

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W6A.27

Entanglement Blocking in DLCZ-Based Networks

Presenter: Ian Tillman , *University of Arizona*

Resource and performance dependent blocking mechanisms for entanglement routing in quantum networks are identified and characterized in simulations of a DLCZ architecture under different loss and resource availability conditions.

Authors:Ian Tillman, University of Arizona / Daniel Kilper, University of Arizona / Abdella Battou, National Institute of Standards and Technology

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W6A.28

107.6 Tb/s GMI Throughput Over 220 km SSMF Using Discrete C- and L-Band Amplification Across >12 THz

Presenter: Iosif Demirtzioglou , *Huawei Technologies France*

We demonstrate a 107.6-Tb/s GMI throughput in a 3-span 220-km SSMF link employing high-baudrate 95-GBaud CS64QAM signals and fully discrete C- and L-band amplifiers. A total amplification bandwidth in excess of 12 THz is achieved.

Authors:Iosif Demirtzioglou, Huawei Technologies France / Djalal Bendimerad, Huawei Technologies France / Ivan Fernandez de Jauregui Ruiz, Huawei Technologies France / Dylan Le Gac, Huawei Technologies France / Abel Lorences-Riesgo, Huawei Technologies France / Nayla El Dahdah, Huawei Technologies France / Antonin Gallet, Huawei Technologies France / Hajar Elfaiki, Huawei Technologies France / Shuqi Yu, Huawei Technologies France / Ge Gao, Huawei Technologies France / Salma Escobar-Landero, Huawei Technologies France / Romain Brenot, Huawei Technologies France / Yann Frignac, Huawei Technologies France / Gabriel Charlet, Huawei Technologies France

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W6A.29

Non-Volatile Operation of a Si PN Ring Resonator With a Ferroelectric Capacitor

Presenter: Seung-min Han , *Korea Institute of Science & Technology*

We demonstrated the non-volatile operation of a Si PN ring resonator with a ferroelectric $HfZrO_2$ capacitor. Due to the polarization in the $HfZrO_2$ capacitor, the resonance wavelength of the ring resonator shows the bi-stable operation.

Authors:Seung-min Han, Korea Institute of Science & Technology / Dae-Won Rho, Yonsei University / Dae-Hwan Ahn, Korea Institute of Science & Technology / Jin-Dong Song, Korea Institute of Science & Technology / Woo-Young Choi, Yonsei University / Jae-Hoon Han, Korea Institute of Science & Technology

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W6A.3

Low Power Consumption Silicon Photonics Datacenter Interconnects Enabled by a Parallel Architecture

Presenter: Aditya Malik , *ECE Department, UCSB*

An architecture is presented for realizing 1 Tbps datacenter interconnects using energy efficient silicon photonics ring modulators and QD-MLL. Both these components show excellent agreement with design parameters. High efficiency EO tuners are also reported.

Authors:Aditya Malik, ECE Department, UCSB / Songtao Liu, ECE Department, UCSB / Erman Timurdogan, Analog Photonics / Mark Harrington, ECE Department, UCSB / Andrew Netherton, ECE Department, UCSB / Mitra Saeidi, ECE Department, UCSB / Daniel Blumenthal, ECE Department, UCSB / Luke Theogarajan, ECE Department, UCSB / Michael Watts, Analog Photonics / John Bowers, ECE Department, UCSB

W6A.30

Low-Complexity Symbol-Rate Rx DSP for Short-Reach Optical Coherent Transmission Systems

Presenter: Jianhong Ke , *Huawei Technologies Canada Research Center*

We propose an efficient low-power symbol-rate Rx DSP scheme for short-reach optical coherent systems targeting DCI scenarios. Compared with typical sampling rate of 2 sample/symbol, the power consumption of both Rx DSP and ADC can be reduced by ~50%.

Authors:Jianhong Ke, Huawei Technologies Canada Research Center / Zilong He, Huawei Technologies Beijing Research Center / Chao Xin, Huawei Technologies Wuhan Research Center / Ting Yang, Huawei Technologies Wuhan Research Center / Chuandong Li, Huawei Technologies Canada Research Center

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W6A.31

Linewidth Limit of a Single Longitude-Mode Fiber Laser With Different Cavity Length

Presenter: Jianming Shang , *Beijing Univ of Posts & Telecom*

Limit of a single-longitudinal-mode erbium-doped fiber laser is experimentally demonstrated. With the increase of cavity length, we obtain an SLM EDFL with an ultra-high OSNR of 76 dB and an ultra-narrow linewidth of 365 Hz.

Authors:Jianming Shang, Beijing Univ of Posts & Telecom / Siqiao Li, Beijing Univ of Posts & Telecom / zhengkang wang, Beijing Univ of Posts & Telecom / Yaojun Qiao, Beijing Univ of Posts & Telecom / song yu, Beijing Univ of Posts & Telecom

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W6A.32

EML-Based 200-Gbit/s/λ DMT Signal Transmission Over 10-km SSMF Using Entropy Loading and Simplified Volterra Equalization

Presenter: Jing Zhang , *Univ of Electronic Science & Tech China*

We propose a joint entropy loading and simplified Volterra filter (VF) to experimentally demonstrate a 200-Gb/s DMT signal transmission over 10-km SSMF using a 32-GHz EML. The BER is below 20% SD-FEC threshold.

Authors:Jing Zhang, Univ of Electronic Science & Tech China / Qun Liu, Univ of Electronic Science & Tech China / Mingyue Zhu, Univ of Electronic Science & Tech China / Hong Lin, Univ of Electronic Science & Tech China / shaohua Hu, Univ of Electronic Science & Tech China / Xingwen Yi, Sun Yat-Sen University / Kun Qiu, Univ of Electronic Science & Tech China

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W6A.33

Power Efficiency in Submarine Systems Using Various Capacity Metrics

Presenter: John Downie , *Corning Inc*

We evaluate link SNR values that maximize power efficiency in submarine systems with various approaches to evaluate capacity and power consumption. The optimal SNR increases with more practical capacity and power measures.

Authors:John Downie, Corning Inc / Xiaojun Liang, Corning Inc / Petr Sterlingov, Corning Inc

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W6A.34

Experimental Demonstration of a Silicon-Photonics WDM NFT Soliton Transmitter

Presenter: Jonas Koch , *Kiel University*

We experimentally demonstrate a silicon-photonics transmitter capable of modulating and optically merging solitons with different frequency and time spacing based on the nonlinear Fourier-transform, offloading electronics. Two soliton channels successfully transmit up to 5000 km.

Authors:Jonas Koch, Kiel University / Alvaro Moscoso-Martir, RWTH Aachen University / Juliana Müller, RWTH Aachen University / Alireza Tabatabaei Mashayekh, RWTH Aachen University / Arka Dipta Das, RWTH Aachen University / Florian Merget, RWTH Aachen University / Stephan Pachnicke, Kiel University / Jeremy Witzens, RWTH Aachen University

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W6A.35

Analysis of the Extremes of SNR Time Series Data Using Extreme Value Statistics

Presenter: Josh Nevin , *University of Cambridge*

We demonstrate the suitability of extreme value statistics for the analysis of the extreme values of SNR time series data from a deployed network. Underlying theory, potential use cases and practical considerations are discussed.

Authors:Josh Nevin, University of Cambridge / Seb Savory, University of Cambridge

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W6A.36

Scalable Federated Learning Over Passive Optical Networks

Presenter: Jun Li , *Chalmers University of Technology*

Two-step aggregation is introduced to facilitate scalable federated learning (SFL) over passive optical networks (PONs). Results reveal that the SFL keeps the required PON upstream bandwidth constant regardless of the number of involved clients, while bringing 10% learning accuracy improvement.

Authors:Jun Li, Chalmers University of Technology / Jiajia Chen, Chalmers University of Technology / Lei Chen, Research Institutes of Sweden

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W6A.37

Photonic Gateway for Direct and Protocol-Independent End-to-End User Connections

Presenter: Kazuaki Honda , *NTT Corporation*

We propose the Photonic Gateway to provide direct and protocol-independent optical connections between any two user sites. An experimental demonstration verifies the feasibility of the Photonic Gateway and an optical-path setup procedure of the prototypes.

Authors:Kazuaki Honda, NTT Corporation / Takuya Kanai, NTT Corporation / Yasunari Tanaka, NTT Corporation / Kazutaka Hara, NTT Corporation / Shin Kaneko, NTT Corporation / Jun-ichi Kani, NTT Corporation / Tomoaki Yoshida, NTT Corporation

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W6A.38

Theory of Spontaneous Emission Factors of Optical Parametric Amplifiers

Presenter: Kazuro Kikuchi , *National Inst. for Academic Degrees*

This study analyzes the effect of the internal loss of optical parametric amplifiers on their noise characteristics. Quantum-mechanical Langevin equations are used to derive theoretical expressions for the spontaneous emission factor for the first time.

Authors:Kazuro Kikuchi, National Inst. for Academic Degrees

W6A.39

Dynamic Decoding of Zipper Codes

Presenter: Kechao Huang , *Huawei Technologies France*

We propose a novel dynamic decoding architecture for both Staircase and Zipper decoders, which can support 400Gbps throughput and achieve more than 80% of complexity reduction compared to the traditional window decoders.

Authors:Kechao Huang, Huawei Technologies France / Shiyao Xiao, Huawei Technologies Co. Ltd. / Deyuan Chang, Huawei Technologies Canada / Xiaoling Yang, Huawei Technologies Co. Ltd. / Qinhui Huang, Huawei Technologies Co. Ltd. / Huixiao Ma, Huawei Technologies Co. Ltd. / Raymond Leung, Huawei Technologies Co. Ltd.

W6A.4

Reservoir Computing Based on Mutually Injected Phase Modulated Lasers: a Monolithic Integration Approach Suitable for Short-Reach Communication Systems

Presenter: Kostas Sozos , *University of West Attica*

We propose a reservoir computing system consisting of two mutually coupled phase modulated lasers. The scheme can be monolithic integrated and extends the reach of 25Gbaud PAM-4 signals up to 55 km in the C-band.

Authors:Kostas Sozos, University of West Attica / Charis Mesaritakis, University of the Aegean / Adonis Bogris, University of West Attica

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W6A.40

Demonstration of Asynchronous Successive Interference Canceller for Uplink NOMA-PON

Presenter: Kosuke Suzuoki , *Osaka University*

This paper proposes a successive interference canceller (SIC) with carrier frequency offset (CFO) compensator for uplink transmission in a non-orthogonal multiple access (NOMA)-based coherent PON. We experimentally confirmed SIC's error-free operation when multiplexing 2 ONUs.

Authors:Kosuke Suzuoki, Osaka University / Daisuke Hisano, Osaka University / Ken Mishina, Osaka University / Kazuki Maruta, Tokyo Institute of Technology / Akihiro Maruta, Osaka University

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W6A.41

Mode Division Multiplexing on Standard 50/125 µm Multi Mode Fiber Using Photonic Lanterns

Presenter: Lars Grüner-Nielsen , *DTU Fotonik, Tech. University of Denmark*

For the first time, direct detection MIMO free mode division multiplexing over standard multi mode fibers, is demonstrated using photonic lantern mode multiplexers. Stable transmission performance is demonstrated over 1.6 km independent of input polarization.

Authors:Lars Grüner-Nielsen, DTU Fotonik, Tech. University of Denmark / Neethu Mathew, DTU Fotonik, Tech. University of Denmark / Magnus Nymann, DTU Fotonik, Tech. University of Denmark / Mads Lillieholm, DTU Fotonik, Tech. University of Denmark / Michael Galili, DTU Fotonik, Tech. University of Denmark / Karsten Rottwitt, DTU Fotonik, Tech. University of Denmark

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W6A.42

DAC-Less and DSP-Free 20 Gb/s PAM-4 Transmission Based on a Dual Modulation Scheme Using DML and External Modulation

Presenter: Laurent Bramerie , *Institut FOTON*

The generation of DAC-less 20 Gb/s PAM-4 using a DML and an external modulator is demonstrated. This dual modulation scheme has been transmitted up to 75 km SSMF with similar performance to PAM-4 DAC transmitter.

Authors:Laurent Bramerie, Institut FOTON / Sebastien Lobo, Institut FOTON / Mathilde Gay, Institut FOTON

W6A.43

Brillouin Phase Spectrum Recovery Based on Kramers-Kronig Relation in Direct-Detection BOTDA Sensors

Presenter: Keyan Zeng , *Huazhong University of Sci. & Tech.*

Without the need of coherent detection and hardware modification, Brillouin phase spectrum is digitally recovered for the first time from the Brillouin gain spectrum based on Kramers-Kronig relation in a conventional direct-detection BOTDA sensing system.

Authors:Keyan Zeng, Huazhong University of Sci. & Tech. / Liang Wang, Huazhong University of Sci. & Tech. / Ming Tang, Huazhong University of Sci. & Tech. / deming liu, Huazhong University of Sci. & Tech.

W6A.44

Demonstration of Slice Fault Monitoring and Handling for Converged Optical-Wireless Access Networks

Presenter: Lianyu Wu , *Beijing University of Posts and Telecomm*

We designed and experimentally demonstrate a RAN slice management system which supports fault monitoring and handling. The system can not only quickly build RAN slices that meet user needs, but also can automatically and timely complete fault handling and service recovery when RAN slice resources fail.

Authors:Lianyu Wu, Beijing University of Posts and Telecomm / Jiabin Cui, Beijing University of Posts and Telecomm / Jiawei Zhang, Beijing University of Posts and Telecomm / Yuefeng Ji, Beijing University of Posts and Telecomm

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W6A.45

Uncertainty Analysis for Failure Prediction in Optical Transport Network Using Bayesian Neural Network

Presenter: Lingling Wang , *Beijing University of Posts and Telecommunications*

A Bayesian neural network-based uncertainty analysis technique is proposed for failure prediction in optical transport network, which can not only achieve F1-score up to 99.5%, but also give an uncertainty quantification for the prediction results.

Authors:Lingling Wang, Beijing University of Posts and Telecommunications / Danshi Wang, Beijing University of Posts and Telecommunications / Chunyu Zhang, Beijing University of Posts and Telecommunications / Songlin Liu, Beijing University of Posts and Telecommunications / Min Zhang, Beijing University of Posts and Telecommunications

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W6A.46

Broadband Polarization Beam Splitters Based on MMI Couplers With Internal Photonic Crystals Fabricated Using 193 nm Photolithography

Presenter: Luhua Xu , *McGill University*

We demonstrate a silicon photonic MMI-coupler-based polarization beam splitter, fabricated using 193 nm photolithography. Measured extinction ratios beyond 30 dB and insertion losses below 3 dB are achieved over a record bandwidth of 111 nm.

Authors:Luhua Xu, McGill University / Deng Mao, McGill University / Jinsong Zhang, McGill University / Yun Wang, McGill University / Zhenping Xing, McGill University / Md Samiul Alam, McGill University / Maxime Jacques, McGill University / Yannick D'Mello, McGill University / Santiago Bernal, McGill University / David Plant, McGill University

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W6A.47

Experimental Verification of 64-Gbd/64-QAM Interworking of Probabilistic Shaping With a Digital Resolution Enhancer

Presenter: Mahmood Aburomoh , *Aston University*

We present an experimental study of probabilistic constellation shaping gains in low resolution digital-to-analogue converter based transceivers, which utilizes digital resolution enhancement. A SNR gain of 0.65dB for optimized probabilistic shaping factors can be achieved

Authors:Mahmood Aburomoh, Aston University / Tu Nguyen, Aston University / Pavel Skvortcov, Aston University / Yaron Yoffe, Ben-Gurion University of the Negev / Ian Phillips, Aston University / Tomislav Drenski, Socionext Europe GmbH / Wladek Forysiak, Aston University

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W6A.48

Stateful DBA Hypervisor Supporting SLAs With Low Latency & High Availability in Shared PON

Presenter: Marco Ruffini , *University of Dublin Trinity College*

We present a stateful DBA hypervisor for shared PONs capable of meeting specific flow-level service level agreements, supporting services requiring strict latency and high availability. We report considerable improvement compared to standard stateless priority-based mechanisms.

Authors:Frank Slyne, University of Dublin Trinity College / Sanwal Zeb, University of Dublin Trinity College / Marco Ruffini, University of Dublin Trinity College

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W6A.49

Inverse-Designed InP-Based Polarization Rotator-Splitter

Presenter: HENDRIK BOERMA , *Fraunhofer Heinrich-Hertz-Institute*

A size-reduced InP-based inverse-designed polarization rotator-splitter is presented, being the first demonstration of a topology-optimized passive waveguide component on InP. The manufactured device has extinction ratios >10dB for both polarizations over the entire C-band.

Authors:Marko Perestjuk, Fraunhofer Heinrich-Hertz-Institute / HENDRIK BOERMA, Fraunhofer Heinrich-Hertz-Institute / Alexander Schindler, Fraunhofer Heinrich-Hertz-Institute / Shahram Keyvaninia, Fraunhofer Heinrich-Hertz-Institute / Patrick Runge, Fraunhofer Heinrich-Hertz-Institute / Martin Schell, Fraunhofer Heinrich-Hertz-Institute

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W6A.5

System-Level Inverse Design for Stokes Receivers on a Commercial Foundry Platform

Presenter: Alec Hammond , *Georgia Institute of Technology*

Using our novel inverse design methodology we design a compact silicon photonic Stokes vector receiver for a commercial foundry. The receiver is comprised of a polarization splitter, polarization rotator, power splitter, and 90^{o} hybrid.

Authors:Alec Hammond, Georgia Institute of Technology / Stephen Ralph, Georgia Institute of Technology

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W6A.50

C-Band 4×200 Gbit/s Transmission Over 40 km of SSMF With an RF Delay-Assisted WDM-SSB Transmitter

Presenter: Md Samiul Alam , *McGill University*

We present an RF-delay assisted cost-effective WDM-SSB transmitter using a single DAC per wavelength, and experimentally demonstrate the transmission of net 4×200 Gbit/s DWDM SSB PS-PAM-8 signals over 40 km of SSMF in the C-band.

Authors:Md Samiul Alam, McGill University / Xueyang Li, McGill University / Zhenping Xing, McGill University / Mohammad E. Mousa-Pasandi, Ciena Corporation / Maurice O'Sullivan, Ciena Corporation / David Plant, McGill University

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W6A.51

Hyperscale Datacenter Networks With Hybrid Fabric Aggregator Architectures

Presenter: Md. Nooruzzaman , *Ryerson University*

We propose a novel datacenter architecture called *hybrid fabric aggregator* that can connect over 1 Million servers. This design offers higher scalability, lower path cost and lower power consumptions compared to the Facebook F16 topology.

Authors:Md. Nooruzzaman, Ryerson University / Xavier Fernando, Ryerson University

W6A.6

Dynamic Auto-Negotiation With Real-Time Transponders in Software Defined Optical Networks

Presenter: Alexandre GOUIN , *Nokia Bell Labs*

We designed a transponder with dynamic auto-negotiation allowing fast detection of performance degradation and reconfiguration. We implemented a proof-of-concept using a commercial transponder, FPGA, and Raspberry Pi. We assessed the performance in terms of latency.

Authors:Alexandre GOUIN, Nokia Bell Labs / Arnaud Dupas, Nokia Bell Labs / Lluis Gifre Renom, Nokia Bell Labs / Ahmed Benabdallah, Nokia Bell Labs / Fabien Boitier, Nokia Bell Labs / Patricia Layec, Nokia Bell Labs

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W6A.7

Multi-Chiplet System Architecture With Shared Uniform Access Memory Based on Board-Level Optical Interconnects

Presenter: Arastu Sharma , *University of Cambridge*

We propose a new multi-chiplet system architecture based on shared uniform memory access and on-board optical interconnects. System-level simulation results demonstrate that such systems offer improved execution times and energy efficiency over conventional computing architectures.

Authors:Arastu Sharma, University of Cambridge / Nikos Bamiedakis, University of Cambridge / Fotini Karinou, Microsoft Research Cambridge / Richard Penty, University of Cambridge

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W6A.8

Photonic Spiking VCSEL Neurons Using Multi-Frequency Switching

Presenter: BangQi Fu , *Shanghai Jiaotong University*

We propose an approach to generate neuron-like spikes of VCSELs by multi-frequency switching. A frequency modulation is realized by numerical simulation to obtain stable spiking response of up to 1 Gbps.

Authors:BangQi Fu, Shanghai Jiaotong University / Wenjia Zhang, Shanghai Jiaotong University / Yao Lu, Shanghai Jiaotong University / Zuyuan He, Shanghai Jiaotong University

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W6A.9

Polarization Rotation Enhanced Nonlinear-Optical Loop Mirror (PR-NOLM) Multilevel Amplitude Regenerator

Presenter: Biao Guo , *UESTC*

We proposed a polarization rotation enhanced nonlinear-optical loop mirror (PR-NOLM)-based multilevel amplitude regenerator to significantly improve the noise suppression performance, achieving the total improvement including 188% of regeneration-range and 4.5dB SNR in the novel scheme.

Authors:Biao Guo, UESTC / Feng Wen, UESTC / Baojian Wu, UESTC / Kun Qiu, UESTC

19:00 - 21:00 Pacific Time (US & Canada) (UTC - 07:00)

W7A

Emerging Advances in Optical Transceiver Technologies

Presider: Reza Motaghian

W7A.1

Prototype of DSP-Free IM/DD MDM Transceiver Based on Multiple-Ring-Core FMF for Datacenter Interconnection

Invited

Presenter: Juhao Li , *Peking University*

We demonstrate the first prototype system of real-time IM/DD MDM transmission with 4 LP modes over 10-km multiple-ring-core FMF. Scalability of the proposed system is discussed and new transmission impairment of Intra-LP-mode dispersion is evaluated.

Authors:Yuyang Gao, Peking University / Dawei Ge, Peking University / Lei Shen, YOFC / Yongqi He, Peking University / Zhangyuan Chen, Peking University / Guifang Li, University of Central Florida / Juhao Li, Peking University

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W7A.2

Demonstration of a Tunable, Broadband Pixel-Array-Based Photonic-Integrated-Circuit Receiver for Recovering Two 100-Gbit/s QPSK Orbital-Angular-Momentum Multiplexed Channels

Presenter: Hao Song , *University of Southern California*

We demonstrate recovering two 100-Gbit/s QPSK OAM-multiplexed channels by using a pixel-array-based integrated receiver. It can be tuned to receive OAM l=+1 or l=-1 with a ~6-nm bandwidth for achieving BER under 7% FEC limit.

Authors:Hao Song, University of Southern California / Huibin Zhou, University of Southern California / Kaiheng Zou, University of Southern California / Runzhou Zhang, University of Southern California / Kai Pang, University of Southern California / Haoqian Song, University of Southern California / Xinzhou Su, University of Southern California / Amir Minoofar, University of Southern California / Nanzhe Hu, University of Southern California / Cong Liu, University of Southern California / Robert Bock, R-Dex System / Brittany Lynn, Naval Information Warfare Center Pacific / Shlomo Zach, Tel Aviv University / Moshe Tur, Tel Aviv University / Alan Willner, University of Southern California

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W7A.3

Hybrid-Integrated 400G TROSA Module and Its Performance Evaluation Using PAM4 DSP Chip

Presenter: Seokjun Yun , *ETRI*

We report on performance evaluation of a hybrid-integrated 4x100G TROSA module using a PAM4 DSP chip. Stable transmission and reception of 106-Gbps/λ PAM4 signals are demonstrated, fully satisfying the 400G-LR4 MSA specifications.

Authors:Seokjun Yun, ETRI / Young-Tak Han, ETRI / Seok-Tae Kim, ETRI / Jang-Uk Shin, ETRI / Sang-Ho Park, ETRI / Donghoon Lee, ETRI / Seo-Young Lee, ETRI / Yongsoon Baek, ETRI

W7A.4

Self-Tuning Bidirectional 50GBASE-ER Optical Transceiver Based on Temperature Control and Silica-Based Comb Filter

Presenter: Dong Wang , *China Mobile Research Institute*

Error-free 24-hour real-time transmission of self-tuning bidirectional 50GBASE-ER QSFP28 point-to-point system over 40-km G.652.D fiber is demonstrated. With the upstream and downstream wavelength in same spectral band, the time-delay is reduced to 0.25 ns.

Authors:Dong Wang, China Mobile Research Institute / Yongpeng Zhao, QXP Technologies Inc. / Jiang Sun, China Mobile Research Institute / Dawei Ge, China Mobile Research Institute / Qian Cai, China Mobile Research Institute / Yunbo Li, China Mobile Research Institute / Yang Zhao, China Mobile Research Institute / Liuyan Han, China Mobile Research Institute / Zhiguang Xu, QXP Technologies Inc. / Dechao Zhang, China Mobile Research Institute / Han Li, China Mobile Research Institute

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W7A.5

Impairment Identification for PAM-4 Transceivers and Links Using Machine Learning

Presenter: Daniel Lippiatt , *Georgia Institute of Technology*

We demonstrate simultaneous TDECQ estimation and impairment identification using convolutional neural networks. Robust training with representative impairments yielded identification accuracy of 100% for TDECQ >2.6 dB, when considering limited bandwidth, signal compression and SNR degradation.

Authors:Daniel Lippiatt, Georgia Institute of Technology / Alirio Melgar, Georgia Institute of Technology / Varghese Thomas, Georgia Institute of Technology / Siddharth Varughese, Georgia Institute of Technology / Pavel Zivny, Tektronix / Shane Hazzard, Tektronix / Stephen Ralph, Georgia Institute of Technology

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W7B

Multi-core Fibers 2

Presider: Taiji Sakamoto

W7B.1

Dynamic Skew in Multi-Core Fibers: From Lab Measurements to Field Trials

Invited

Presenter: Ruben Luis , *National Inst of Information & Comm Tech*

We review recent works on the analysis of inter-core skew in multi-core fibers, comparing the behaviors of spooled fibers in laboratory conditions with field deployed fibers.

Authors:Ruben Luis, National Inst of Information & Comm Tech / Benjamin Puttnam, National Inst of Information & Comm Tech / Georg Rademacher, National Inst of Information & Comm Tech / Andrea Marotta, Universty of L'Aquila / Cristian Antonelli, Universty of L'Aquila / Fabio Graziosi, Universty of L'Aquila / Antonio Mecozzi, Universty of L'Aquila / Tetsuya Hayashi, Sumitomo Electric Industries, Ltd / Tetsuya Nakanishi, Sumitomo Electric Industries, Ltd / Satoshi Shinada, National Inst of Information & Comm Tech / Yoshinari Awaji, National Inst of Information & Comm Tech / Hideaki Furukawa, National Inst of Information & Comm Tech / Naoya Wada, National Inst of Information & Comm Tech

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W7B.2

Weakly-Coupled MCF Direct-Detection OOK Systems Impaired by Laser Phase Noise

Invited

Presenter: Tiago Alves , *Instituto De Telecomunicacoes*

On-off-keying multicore fiber systems employing different lasers are experimentally investigated. Laser phase noise increases the instantaneous fluctuations of the crosstalk. DFB-based systems may require an additional crosstalk margin of 4 dB relative to ECL-based systems.

Authors:Tiago Alves, Instituto De Telecomunicacoes / Joao Rebola, Instituto De Telecomunicacoes / Adolfo Cartaxo, Instituto De Telecomunicacoes

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W7B.3

Distributed Measurement of Birefringence in Uncoupled Multicore Fibers

Presenter: Luca Palmieri , *University of Padova*

We report the results of the first distributed measurement of local birefringence performed on a nominally-uncoupled four-core fiber. The data show correlation betweenthe intrinsic birefringence of the individual cores.

Authors:Riccardo Veronese, University of Padova / Cristian Antonelli, University of L'Aquila / Antonio Mecozzi, University of L'Aquila / Tetsuya Hayashi, Sumitomo Electric Industries, Ltd. / Marco Santagiustina, University of Padova / Andrea Galtarossa, University of Padova / Luca Palmieri, University of Padova

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W7B.4

Distributed Measurement of the Shape of Microbends in Optical Fibers

Presenter: Raja Ahmad , *OFS Laboratories*

We present the distributed shape measurement of microbends in a twisted multicore optical fiber. The measurement resolution of the fiber shape reconstruction is ~40 μm in the longitudinal domain and sub-micron in the transverse domain.

Authors:Raja Ahmad, OFS Laboratories / Wing Ko, OFS Laboratories / Kenneth Feder, OFS Laboratories / Paul Westbrook, OFS Laboratories

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W7B.5

Multicore Optical Fibers and Devices: Design, Manufacturing and Applications

Invited

Presenter: Jose Antonio-Lopez , *University of Central Florida, CREOL*

We report recent advances in the fabrication of multicore and multimode fibers, amplifiers, and devices for space division multiplexing. Low-loss and low-crosstalk fibers and devices can be achieved by carefully optimizing the fabrication processes.

Authors:Jose Antonio-Lopez, University of Central Florida, CREOL / Juan Carlos Alvarado, University of Central Florida, CREOL / Steffen Wittek, University of Central Florida, CREOL / Daniel Cruz Delgado, University of Central Florida, CREOL / Julian Martinez Mercado, University of Central Florida, CREOL

W7C

Distributed Fiber Lasing and Sensing

Presider: Raja Ahmad

W7C.1

Spatio-Temporal Oversampling-Downsampling Technique for High SNR Fiber Distributed Acoustic Sensing

Presenter: Hao Li , *Huazhong Univ of Science and Technology*

A spatio-temporal oversampling-downsampling fiber DAS system is proposed and demonstrated. Without increasing the complexity and cost of the system, the demodulated SNR can be increased by 15dB, and the fading noise can be completely eliminated.

Authors:Hao Li, Huazhong Univ of Science and Technology / Cunzheng Fan, Huazhong Univ of Science and Technology / Tao Liu, Huazhong Univ of Science and Technology / Tao He, Huazhong Univ of Science and Technology / Junfeng Chen, Huazhong Univ of Science and Technology / Yixiang Sun, Huazhong Univ of Science and Technology / Zhijun Yan, Huazhong Univ of Science and Technology / Qizhen Sun, Huazhong Univ of Science and Technology

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W7C.2

An OFDM-MIMO Distributed Acoustic Sensing Over Deployed Telecom Fibers

Presenter: Sterenn Guerrier , *Nokia Bell-Labs*

We demonstrate the performance of a novel multi-carrier MIMO fiber sensing interrogator based on OFDM approach. Over an installed telecom fiber cable, coherent fading is mitigated by means of a purely digital subcarrier combiner.

Authors:Christian Dorize, Nokia Bell-Labs / Sterenn Guerrier, Nokia Bell-Labs / Elie Awwad, Telecom-Paris / Peter Nwakamma, Nokia Bell-Labs / Haik Mardoyan, Nokia Bell-Labs / Jeremie Renaudier, Nokia Bell-Labs

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W7C.3

Fully Distributed Hydroacoustic Sensing Based on Lightweight Optical Cable Assisted With Scattering Enhanced Fiber.

Presenter: Junfeng Chen , *Huazhong Univ of Science and Technology*

We design a lightweight fiber optical hydrophone cable based on scattering enhanced fiber. Combined with distributed acoustic sensing technology, it realizes fully distributed hydroacoustic sensing with an ultra-high sensitivity up to −127dB (*re* rad/*μ*Pa).

Authors:Junfeng Chen, Huazhong Univ of Science and Technology / Hao Li, Huazhong Univ of Science and Technology / Tao Liu, Huazhong Univ of Science and Technology / Cunzheng Fan, Huazhong Univ of Science and Technology / Zhijun Yan, Huazhong Univ of Science and Technology / Qizhen Sun, Huazhong Univ of Science and Technology

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W7C.4

Experimental Demonstration of Phase-Sensitive OTDR With Adaptive Probe-Pulse Modulation

Presenter: Yongxin Liang , *Univ. Electronic Sci. & Tech. of China*

With deep learning, the restoration of phase-sensitive OTDR impulse response is achieved with double rectangular test pulses, thereafter optimal probe-pulse is designed to suppress interference fading at designated zone.

Authors:Yongxin Liang, Univ. Electronic Sci. & Tech. of China / Zinan Wang, Univ. Electronic Sci. & Tech. of China / Shengtao Lin, Univ. Electronic Sci. & Tech. of China / Yun-Jiang Rao, Univ. Electronic Sci. & Tech. of China

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W7C.5

Highly Stabilized Brillouin Random Fiber Laser Based on Self-Inscribed Dynamic Fiber Grating

Presenter: Zenghuan Qiu , *Shanghai University*

A self-inscribed dynamic fiber grating as an auto-tracking mode selective element is embedded into a Brillouin random fiber laser, yielding a frequency stabilized Stokes random lasing radiation with highly suppressed modes hoping.

Authors:Zenghuan Qiu, Shanghai University / Zhelan Xiao, Shanghai University / Jilin Zhang, Shanghai University / Haoran Xie, Shanghai University / Yikun Jiang, Shanghai University / Fufei Pang, Shanghai University / Liang Zhang, Shanghai University

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W7C.6

Distributed Acoustic Wave Sensing in a Brillouin Random Fiber Laser

Presenter: Zichao Zhou , *Univiersity of Ottawa*

The distributed acoustic wave is associated with the Brillouin gain buildup and saturation in Brillouin random fiber laser (BRFL). At laser threshold, the probability of optical rogue waves is 2.5 times at maximum gain location of the low gain region, and power saturation appeared above threshold at high gain location.

Authors:Zichao Zhou, Univiersity of Ottawa / Haiyang Wang, Univiersity of Ottawa / Yuan Wang, Univiersity of Ottawa / Liang Chen, Univiersity of Ottawa / Xiaoyi Bao, Univiersity of Ottawa

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W7C.7

Fiber Lasers With Regular and Random Distributed Feedback

Invited

Presenter: Sergey Babin , *Institute of Automation and Electrometry*

We review our resent results on fiber lasers with distributed feedback (DFB) based on π-shifted fiber Bragg grating (FBG), random FBG array and random index structure inscribed by fs pulses in singlemode or multicore/multimode fibersct not available.

Authors:Sergey Babin, Institute of Automation and Electrometry / Alexey Kuznetsov, Institute of Automation and Electrometry / Alexey Wolf, Institute of Automation and Electrometry / Mikhail Skvortsov, Institute of Automation and Electrometry / Alexandr Dostovalov, Institute of Automation and Electrometry / Sergey Kablukov, Institute of Automation and Electrometry / Evgeniy Podivilov, Institute of Automation and Electrometry / Stefan Wabnitz, Novosibirsk State University

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W7D

SDM Transmission

Presider: Oleg Sinkin

W7D.1

High Capacity and Long-Haul Transmission With Space-Division Multiplexing

Invited

Presenter: Georg Rademacher , *National Inst of Information & Comm Tech*

We report on recent wideband, high-capacity transmission experiments using either few-mode or coupled-core multi-core fibers. We show that the coupled-core MCF has overall favorable transmission properties at the cost of a lower spatial channel density.

Authors:Georg Rademacher, National Inst of Information & Comm Tech / Ruben Luis, National Inst of Information & Comm Tech / Benjamin Puttnam, National Inst of Information & Comm Tech / Roland Ryf, Nokia Bell Labs / Sjoerd van der Heide, TU Eindhoven / Tobias Eriksson, Infinera / Nicolas Fontaine, Nokia Bell Labs / Haoshuo Chen, Nokia Bell Labs / Rene-Jean Essiambre, Nokia Bell Labs / Yoshinari Awaji, National Inst of Information & Comm Tech / Hideaki Furukawa, National Inst of Information & Comm Tech

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W7D.2

Long-Haul WDM/SDM Transmission Over Coupled 4-Core Fiber With Coupled 4-Core EDFA and Its MDL Characteristics Estimation

Presenter: Manabu Arikawa , *NEC Corporation*

We demonstrated WDM/SDM transmission of 32-Gbaud PDM-QPSK over coupled 4-core fibers and EDFAs with error-free after FEC for up to 2400 km. We estimated that rms MDL of 1.1 dB per loop was limiting performance.

Authors:Manabu Arikawa, NEC Corporation / Kohei Hosokawa, NEC Corporation / Kazunori Hayashi, Kyoto University

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W7D.3

50.47-Tbit/s Standard Cladding Ultra-Low-Loss Coupled 4-Core Fiber Transmission Over 9,150 km

Presenter: Daiki Soma , *KDDI Research, Inc.*

50.47-Tbit/s transpacific coupled multi-core fiber transmission has been experimentally demonstrated using standard cladding ultra-low-loss coupled 4-core fibers. The Q-factors of all SDM/WDM channels modulated with 24-Gbaud DP-QPSK exceeded the assumed FEC limits after 9,150-km transmission.

Authors:Daiki Soma, KDDI Research, Inc. / Shohei Beppu, KDDI Research, Inc. / Yuta Wakayama, KDDI Research, Inc. / Seiya Sumita, KDDI Research, Inc. / Hidenori Takahashi, KDDI Research, Inc. / Noboru Yoshikane, KDDI Research, Inc. / Itsuro Morita, KDDI Research, Inc. / Takehiro Tsuritani, KDDI Research, Inc. / Masatoshi Suzuki, KDDI Research, Inc.

W7D.4

Real-Time MIMO-DSP Technologies for SDM Systems

Invited

Presenter: Shohei Beppu , *KDDI Research, Inc.*

We implement an FPGA-based real-time MIMO-DSP for equalizing spatial modes and polarizations. With MIMO-DSP, we demonstrate real-time transmission over weakly coupled 10-mode fibers and strongly coupled 4-core fibers using WDM DP-QPSK signals.

Authors:Shohei Beppu, KDDI Research, Inc. / Koji Igarashi, Osaka University / Masahiro Kikuta, NEC Platforms, Ltd. / Hiroshi Mukai, NEC Platforms, Ltd. / Masahiro Shigihara, NEC Platforms, Ltd. / Yasuo Saito, NEC Platforms, Ltd. / Daiki Soma, KDDI Research, Inc. / Hidenori Takahashi, KDDI Research, Inc. / Noboru Yoshikane, KDDI Research, Inc. / Itsuro Morita, KDDI Research, Inc. / Takehiro Tsuritani, KDDI Research, Inc.

W7D.5

360-Channel WDM-MDM Transmission Over 25-km Ring-Core Fiber Using Low-Complexity Modular 4×4 MIMO Equalization

Presenter: Zhenrui Lin , *Sun Yat-sen University*

Transmission of 12 OAM modes each carrying 30 wavelengths with 11.52-Tbit/s capacity over 25-km specially designed ring-core fiber has been successfully demonstrated, using 4×4 modular MIMO equalization with tap number no more than 25.

Authors:Zhenrui Lin, Sun Yat-sen University / Junyi Liu, Sun Yat-sen University / Jianpei Lin, Sun Yat-sen University / Lei Shen, Yangtze Optical Fiber and Cable Joint Stock Limited Company, State key Laboratory of Optical Fiber and Cable Manufacture technology / Jingxing Zhang, Sun Yat-sen University / Junwei Zhang, Sun Yat-sen University / Shuqi Mo, Sun Yat-sen University / Peng Li, Yangtze Optical Fiber and Cable Joint Stock Limited Company, State key Laboratory of Optical Fiber and Cable Manufacture technology / Lan Deng, Yangtze Optical Fiber and Cable Joint Stock Limited Company, State key Laboratory of Optical Fiber and Cable Manufacture technology / Jie Liu, Sun Yat-sen University / Siyuan Yu, Sun Yat-sen University

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W7E

Free Space Optics

Presider: Baris Erkmen

W7E.1

Experimental Demonstration of a 1-Gbit/s “Pin-Like” Low-Divergence Beam Using a Limited-Sized Receiver Aperture at Various Distances

Presenter: Nanzhe Hu , *Uninversity of Southern California*

We experimentally demonstrate a 1-Gbit/s free-space optical data communication link using a pin-like beam. The results show that the pin-like beam has ~8dB less power loss induced by the limited-size receiver aperture at various distances compared with a Gaussian beam.

Authors:Nanzhe Hu, Uninversity of Southern California / Huibin Zhou, Uninversity of Southern California / Runzhou Zhang, Uninversity of Southern California / Haoqian Song, Uninversity of Southern California / Kai Pang, Uninversity of Southern California / Kaiheng Zou, Uninversity of Southern California / Hao Song, Uninversity of Southern California / Xinzhou Su, Uninversity of Southern California / Cong Liu, Uninversity of Southern California / Brittany Lynn, Space & Naval Warfare Systems Center / Moshe Tur, Tel Aviv University / Alan Willner, Uninversity of Southern California

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W7E.2

240-Gbps SDM-FSO Communication Using 4-Bundle Fiber and 2D Photodetector Array

Presenter: Toshimasa Umezawa , *National Inst of Information & Comm Tech*

We demonstrate a high-data-rate, free-space optical communication through a 4-bundle fiber using a multi-pixel 2D photodetector array. By employing pre-distortion techniques, a 10-Gbaud, 64-QAM signal transmission per channel could be successfully achieved (BER< $1x10^{-3}$).

Authors:Toshimasa Umezawa, National Inst of Information & Comm Tech / Kunio Jitsuno, Waseda University / Naokatsu Yamamoto, National Inst of Information & Comm Tech / Tetsuya Kawanishi, National Inst of Information & Comm Tech

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W7E.3

Demonstration of 100Gbit/s Real-Time Ultra High Definition Video Transmission Over Free Space Optical Communication Links

Presenter: Yueying Zhan , *Chinese Academy of Sciences*

The real-time FSO transmission of 100Gbps 4K-UHD video streams over 2.1km horizontal atmospheric link is successfully demonstrated. Results show that 100Gbps 4K-UHD video can be transmitted with negligible errors in 1000 seconds

Authors:Yueying Zhan, Chinese Academy of Sciences / Yang Sun, Chinese Academy of Sciences / Ziyuan Shi, Chinese Academy of Sciences / Lei Yang, Chinese Academy of Sciences

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W7E.4

Elliptical-Aperture Multimode Diversity Reception for Free-Space Optics Communications Under Anisotropic Turbulence

Presenter: Yetian Huang , *Shanghai University*

We experimentally demonstrate an elliptical-aperture multimode diversity receiver to resist beam wander under anisotropic turbulence. The proposed scheme reduces outage probability from 35% to 1.8% for detecting polarization-diversity 30-Gbaud QPSK signal.

Authors:Yetian Huang, Shanghai University / Hanzi Huang, Shanghai University / Haoshuo Chen, Nokia Bell Labs / Juan Carlos Alvarado, Nokia Bell Labs / Qianwu Zhang, Shanghai University / Nicolas Fontaine, Nokia Bell Labs / Mikael Mazur, Nokia Bell Labs / Roland Ryf, Nokia Bell Labs / Yingchun Li, Shanghai University / Rodrigo Amezcua Correa, University of Central Florida / Yingxiong Song, Shanghai University / Min Wang, Shanghai University

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W7E.5

Demonstration of Free-Space 300-Gbit/s QPSK Communications Using Both Wavelength- and Mode-Division-Multiplexing in the Mid-IR

Presenter: Kaiheng Zou , *University of Southern California*

We demonstrate free-space wavelength- and mode-division-multiplexed communications in the mid-infrared wavelength region. A total capacity of 300 Gbit/s is achieved using three wavelengths and two orbital angular momentum modes each carrying a 50-Gbit/s QPSK signal.

Authors:Kaiheng Zou, University of Southern California / Kai Pang, University of Southern California / Hao Song, University of Southern California / Jintao Fan, Tianjin University / Zhe Zhao, University of Southern California / Haoqian Song, University of Southern California / Runzhou Zhang, University of Southern California / Huibin Zhou, University of Southern California / Amir Minoofar, University of Southern California / Cong Liu, University of Southern California / Xinzhou Su, University of Southern California / Nanzhe Hu, University of Southern California / Andrew McClung, University of Massachusetts Amherst / Mahsa Torfeh, University of Massachusetts Amherst / Amir Arbabi, University of Massachusetts Amherst / Moshe Tur, Tel Aviv University / Alan Willner, University of Southern California

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W7E.6

Fiber-to-Fiber FSO System With Advanced VCM Controlled Laser Beam Pointing and Tracking

Presenter: Abdelmoula Bekkali , *TOYO Electric Corpration*

We evaluate the performance of our fiber-to-fiber FSO transceiver with intelligent VCM-lens-controlled laser beam pointing and tracking. We demonstrate error-free-transmission of 10xLTE-CPRI channels at 6-Gbit/s and 10GbE standards over reflected- and loop-back 2x100m FSO link.

Authors:Abdelmoula Bekkali, TOYO Electric Corpration / Hideo Fujita, TOYO Electric Corpration / Michikazu Hattori, TOYO Electric Corpration

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W7E.7

High-Speed MIMO Communication and Simultaneous Energy Harvesting Using Novel Organic Photovoltaics

Presenter: Iman Tavakkolnia , *The University of Strathclyde*

A data rate of 363-Mb/s is achieved in a multiple-input-multiple-output experiment using 4 organic photovoltaics as receivers. The same system simultaneously extracted 10.9-mW. The resulting system model predicts 133-Gb/s using a 1000-cell organic solar panel.

Authors:Iman Tavakkolnia, The University of Strathclyde / Lethy Jagadamma, University of St Andrews / Rui Bian, pureLiFi / Pavlos Manousiadis, University of St Andrews / Stefan Videv, The University of Strathclyde / Graham Turnbull, University of St Andrews / Ifor Samuel, University of St Andrews / Harald Haas, The University of Strathclyde

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W7E.8

Implementation and Evaluation of 2.5 Gbps Mobile FSO Communication System Based on 2.5 GBASE-T Standard

Presenter: Ji Hyoung Ryu , *Electronics and Telecommunications Research Institute*

We present a full-duplex mobile FSO system that provides a 2.5 Gbps single channel based on the 2.5 GBASE-T standard. We successfully confirm that the data transmitted 2.3 Gbps even in heavy rain and thick smoke.

Authors:Youngsoon Heo, Electronics and Telecommunications Research Institute / Ji Hyoung Ryu, Electronics and Telecommunications Research Institute / Chan Il Yeo, Electronics and Telecommunications Research Institute / Si Woong Park, Electronics and Telecommunications Research Institute / Hyun Seo Kang, Electronics and Telecommunications Research Institute

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W7F

IM-DD for Intra/Inter Data-centers

Presider: Xiaodan Pang

W7F.1

Silicon Photonic MZM Architectures for 200G per Lambda IM/DD Transmission

Invited

Presenter: Maxime Jacques , *McGill University*

We review design considerations for silicon photonic single-segment and multi-segment Mach-Zehnder modulators for net 200 Gbit/s/lane intensity modulation direct detection applications. We consider constraints from both the technology and future standards.

Authors:Maxime Jacques, McGill University / Alireza Samani, McGill University / Eslam El-Fiky, McGill University / David Plant, McGill University

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W7F.2

Low Cost 100Gb/s/λ PAM-4 Signal Transmission for 40-km Inter-DCI With 4-bit Resolution DAC in O-Band

Presenter: Mingzhu Yin , *Sun Yat-Sen University*

Enabled by adaptive notch filter for clock leakage suppression and noise shaping technique for redistribution of quantization noise in DAC, beyond 100Gb/s PAM-4 signal over 40-km SMF transmission in O-band with BER under 3.8×10^{-3} utilizing 4-bit resolution DAC is first experimentally demonstrated in this paper.

Authors:Fan Li, Sun Yat-Sen University / Mingzhu Yin, Sun Yat-Sen University

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W7F.3

Feasibility of Transmitting 270 Gbit/s With PAM-8 in O-Band CWDM4 With IM/DD System

Presenter: Md Sabbir-Bin Hossain , *Huawei Technologies*

We have shown transmission of 270 Gb/s with PAM-8 at each lane of CWDM4 in the O-band up to 2 km. The BER performance in each lane are very similar at 7% HDFEC limit.

Authors:Md Sabbir-Bin Hossain, Huawei Technologies / Talha Rahman, Huawei Technologies / Nebojsa Stojanovic, Huawei Technologies / Tom Wettlin, Kiel University / Stefano Calabro, Huawei Technologies / Jinlong Wei, Huawei Technologies / Changsong Xie, Huawei Technologies / Stephan Pachnicke, Kiel University

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W7F.4

224-Gb/s 16QAM SV-DD Transmission Using Pilot-Assisted Polarization Recovery With Integrated Receiver

Presenter: Sen Zhang , *Huawei Technologies Co Ltd*

We propose and experimentally demonstrate a low-complexity pilot-assisted analytical method for polarization demultiplexing in SV-DD systems, achieving a 224-Gb/s 16QAM transmission over 40-km SSMF and can tolerate up to 75-krad/s RSOP at BTB.

Authors:Sen Zhang, Huawei Technologies Co Ltd / Liwang Lu, South China Normal University / Linsheng Fan, Huawei Technologies Co Ltd / Bin Chen, Zhejiang University / Tingting Zhang, Huawei Technologies Co Ltd / Tianjian Zuo, Huawei Technologies Co Ltd / Lei Liu, Huawei Technologies Co Ltd / Jin Tang, Huawei Technologies Co Ltd / Li Zeng, Huawei Technologies Co Ltd / PENGXIN Chen, South China Normal University / Jiahao Huo, Beijing University of Science and Technology / Xian Zhou, Beijing University of Science and Technology / Alan Lau, The Hong Kong Polytechnic University / Chao Lu, The Hong Kong Polytechnic University / Liu Liu, Zhejiang University / Changjian Guo, South China Normal University

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W7F.5

Error-Feedback Noise Shaping for Low-Resolution High-Speed IM/DD and Coherent Transmission Systems

Presenter: Liang Shu , *Beijing Univ. of Posts and Telecom.*

We investigate the performance of error-feedback noise shaping (EFNS) in low-resolution IM/DD and coherent systems by simulations and experiments. EFNS shows comparable performance to digital resolution enhancer and has advantages of complexity & processing delay.

Authors:Liang Shu, Beijing Univ. of Posts and Telecom. / Zhenming Yu, Beijing Univ. of Posts and Telecom. / Kaixuan Sun, Beijing Univ. of Posts and Telecom. / Zhiquan Wan, Beijing Univ. of Posts and Telecom. / Hongyu Huang, Beijing Univ. of Posts and Telecom. / Kun Xu, Beijing Univ. of Posts and Telecom.

W7F.6

800Gb/s-FR4 Specification and Interoperability Analysis

Presenter: Maxim Kuschnerov , *Huawei Technologies*

<!--WeLinkPC-->Interoperability requirements are discussed for 200Gb/s PAM4 and verified using high-bandwidth electro-absorption modulated lasers (EML) and a concatenated forward error correction (FEC) scheme based on hard-decision zipper code, which can be applied to 800Gb/s-FR4 transmission.

Authors:Maxim Kuschnerov, Huawei Technologies / Yu Tian, Huawei Technologies / Youxi Lin, Huawei Technologies / Jianyu Zheng, Huawei Technologies / Jin Tang, Huawei Technologies / Huixiao Ma, Huawei Technologies / Talha Rahman, Huawei Technologies / Raymond Leung, Huawei Technologies / Lewei Zhang, Huawei Technologies

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W7F.7

Quantization Noise-Aware Partial Pre-Emphasis Model and Experimental Validation in High-Speed IM-DD System

Presenter: qi wu , *Shanghai Jiao Tong university*

We propose a novel theoretical model including both the quantization noise and electrical noise together. A digital partial α-pre-emphasis is defined and validated both numerically and experimentally with 60Gbaud PAM-4 signal in bandwidth-limited IM-DD system.

Authors:qi wu, Shanghai Jiao Tong university / Weisheng Hu, Shanghai Jiao Tong university

Thursday, 10 June

3:00 - 4:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE7

Special Event - Educational Worldwide Lab Tour: Part 2

3:00 - 5:00 Pacific Time (US & Canada) (UTC - 07:00)

Th1A

Joint Poster Session 2

Th1A.1

Interpretable and Visualized SHAP-Based Equalizer With Feature Selection in IMDD System

Presenter: Chenyu Wang , *Hangzhou Dianzi University*

We firstly leveraged the SHAP-based method to visualize and analyze trained equalizer in IMDD-based short-reach system and manifested in bandwidth-limitation PAM-4 system. As a result, half of the features are reduced without deteriorating system performance.

Authors:Chenyu Wang, Hangzhou Dianzi University / Xin Miao, Shanghai Jiao Tong University / Yu Xi, Hangzhou Dianzi University / Meihua Bi, Hangzhou Dianzi University / Longsheng Li, Shanghai Jiao Tong University / Weisheng Hu, Shanghai Jiao Tong University

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Th1A.10

Hardware Comparison of Feed-Forward Clock Recovery Algorithms for Optical Communications

Presenter: Patrick Matalla , *Karlsruhe Institute of Technology, IPQ*

Two feed-forward (FF), non-data aided (NDA) digital clock recovery methods in time and frequency domain are discussed and experimentally evaluated with respect to their real-time performance and digital hardware utilization.

Authors:Patrick Matalla, Karlsruhe Institute of Technology, IPQ / Md Salek Mahmud, Karlsruhe Institute of Technology, IPQ / Christoph Füllner, Karlsruhe Institute of Technology, IPQ / Christian Koos, Karlsruhe Institute of Technology, IPQ / Wolfgang Freude, Karlsruhe Institute of Technology, IPQ / Sebastian Randel, Karlsruhe Institute of Technology, IPQ

Th1A.11

Demonstration of a RF-Source-Free Microwave Photonic Radar Based on an Optically Injected Semiconductor Laser

Presenter: Pei Zhou , *Soochow University*

A novel RF-source-free microwave photonic radar has been proposed and experimentally demonstrated based on an optically injected semiconductor laser. Real-time high-resolution target detection is achieved without the requirement of any external RF sources.

Authors:Pei Zhou, Soochow University / Renheng Zhang, Soochow University / Zhidong Jiang, Soochow University / Nianqiang Li, Soochow University / Shilong Pan, Nanjing University of Aeronautics and Astronautics

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Th1A.12

High Speed, Low Voltage Polarization Controller Based on Heterogeneous Integration of Silicon and Lithium Niobate

Presenter: Zhi Zheng , *South China Normal University*

A high speed, low voltage polarization controller based on Si-LN heterogeneous integration is fabricated and characterized. Vπ of 3.2 - 5.2 V is realized in a frequency range of 60 Hz to 6 MHz.

Authors:Zhi Zheng, South China Normal University / Liwang Lu, South China Normal University / Chijun Li, South China Normal University / Wei Wang, South China Normal University / Sen Zhang, Huawei Technologies Co., Ltd / Linsheng Fan, Huawei Technologies Co., Ltd / Tingting Zhang, Huawei Technologies Co., Ltd / Tianjian Zuo, Huawei Technologies Co., Ltd / Lei Liu, Huawei Technologies Co., Ltd / Alan Lau, The Hong Kong Polytechnic University / Chao Lu, The Hong Kong Polytechnic University / PENGXIN Chen, South China Normal University / Changjian Guo, South China Normal University / Liu Liu, Zhejiang University

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Th1A.13

Laser-Based Nitric Oxide Detection at 5.26 μm Using Antiresonant Hollow-Core Fiber

Presenter: Piotr Jaworski , *Laser & Fiber Electronics Group, Faculty of Electronics, Wroclaw University of Science and Technology*

In this work we report on self-fabricated borosilicate Antiresonant Hollow-Core Fiber enabling low loss light guidance in the Mid-IR and demonstrate its application in nitric oxide sensing at 5.26 μm aided with Wavelength Modulation Spectroscopy.

Authors:Piotr Jaworski, Laser & Fiber Electronics Group, Faculty of Electronics, Wroclaw University of Science and Technology / Grzegorz Dudzik, Laser & Fiber Electronics Group, Faculty of Electronics, Wroclaw University of Science and Technology / Pier Sazio, Optoelectronics Research Centre, University of Southampton / Walter Belardi, Université de Lille, CNRS, UMR 8523 —PhLAM—Physique des Lasers, Atomes et Molécules / Karol Krzempek, Laser & Fiber Electronics Group, Faculty of Electronics, Wroclaw University of Science and Technology

Th1A.14

Impact of Chromatic Dispersion in Discrete Raman Amplifiers on Coherent Transmission Systems

Presenter: Pratim Hazarika , *Aston University*

The impact of chromatic dispersion in discrete Raman amplifiers on coherent transmission systems was investigated. Systems with positive dispersion gain fibre show a SNR improvement of ~1.8 dB for 23-GBaud DP-QPSK signals transmitted over >1800km.

Authors:Pratim Hazarika, Aston University / Mahmood Abu-Romoh, Aston University / Mingming Tan, Aston University / Lukasz Krzczanowicz, Aston University / Tu T. Nguyen, Aston University / Md Asif Iqbal, Aston University / Ian Philips, Aston University / Paul Harper, Aston University / Ming-Jun Li, Corning Incorporated / Wladek Forysiak, Aston University

Th1A.15

Scalable and Reconfigurable True Time Delay Line Based on High Performance Switches

Presenter: Qian Song , *Univ of Electonic Science&Tech of China*

A scalable and reconfigurable optical true time delay line consisting of high performance MZI switch driving by a parallel graphene heater easily scaled to M bit with a slight increase in dimensions was proposed.

Authors:Qian Song, Univ of Electonic Science&Tech of China

Th1A.16

Orbital Angular Momentum (OAM) Recognition With Generative Adversarial Network (GAN) Based Atmospheric Modeling

Presenter: Chenda Lu , *School of Electronic Engineering, State Key Laboratory of Information Photonics and Optical Communications, BUPT*

We proposed a Generative Adversarial Network (GAN) based atmospheric modeling method which helps with the Orbital angular momentum (OAM) recognition to achieve better accuracy with limited data.

Authors:Chenda Lu, School of Electronic Engineering, State Key Laboratory of Information Photonics and Optical Communications, BUPT / Qinghua Tian, School of Electronic Engineering, State Key Laboratory of Information Photonics and Optical Communications, BUPT / Xiangjun Xin, School of Electronic Engineering, State Key Laboratory of Information Photonics and Optical Communications, BUPT / Lei Zhu, School of Electronic Engineering, State Key Laboratory of Information Photonics and Optical Communications, BUPT / Qi Zhang, School of Electronic Engineering, State Key Laboratory of Information Photonics and Optical Communications, BUPT / Haipeng Yao, Beijing Key Laboratory of Space-ground Interconnection and Convergence, BUPT / Huan Chang, Advanced Research Institute of Multidisciplinary Science, Beijing Institute of Technology / Ran Gao, Advanced Research Institute of Multidisciplinary Science, Beijing Institute of Technology

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Th1A.17

A Generalized Pairwise Optimization Accelerator Unit for Designing Geometric Shaping 64-QAM

Presenter: RACHATA MANEEKUT , *KDDI Research Inc.*

An accelerator unit in conjunction with generalized pairwise optimization can obtain optimum geometric shaped 64QAM constellations up to 60% faster. Shaping gain and transmission distance are improved over just GPO constellations in low-to-middle SNR regimes.

Authors:RACHATA MANEEKUT, KDDI Research Inc. / Daniel Elson, KDDI Research Inc. / Shohei Beppu, KDDI Research Inc. / Hidenori Takahashi, KDDI Research Inc. / Noboru Yoshikane, KDDI Research Inc.

Th1A.18

Channel Matching: an Adaptive Technique to Increase the Accuracy of Soft Decisions

Presenter: Reza Rafie Borujeny , *University of Toronto*

Nonlinear interference is modeled by a time-varying conditionally Gaussian channel. It is shown that approximating this channel with a time-invariant channel imposes considerable loss in the performance of channel decoding. An adaptive method to maintain decoding performance is described.

Authors:Reza Rafie Borujeny, University of Toronto / Frank Kschischang, University of Toronto

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Th1A.19

Towards Co-Existence of 100 Gbps Classical Channel Within a WDM Quantum Entanglement Network

Presenter: Rodrigo Tessinari , *University of Bristol*

We experimentally prove the feasibility of wavelength multiplexing bright 100 Gbps classical communication with multiple single-photon level entanglement channels over SMF-28e fibre in a quantum network. This minimises the resources needed for quantum networks.

Authors:Rodrigo Tessinari, University of Bristol / obada alia, University of Bristol / Siddarth Koduru Joshi, University of Bristol / Djeylan Aktas, University of Bristol / Marcus Clark, University of Bristol / Emilio Hugues-Salas, University of Bristol / George Kanellos, University of Bristol / John Rarity, University of Bristol / Reza Nejabati, University of Bristol / Dimitra Simeonidou, University of Bristol

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Th1A.2

Flexible Bandwidth Allocation Using OFDM in Mode Forming Optical Access Network

Presenter: Miho Akiyama , *Kochi University of Technology,*

Flexible bandwidth allocation using OFDM mode-forming techniques is proposed. 2 channel 6 subcarrier OFDM signals, stabilized by feedback, are transmitted in a conventional GI-MMF and each subcarrier is allocated arbitrary to different output port.

Authors:Miho Akiyama, Kochi University of Technology, / Hirokazu Kobayashi, Kochi University of Technology, / Katsushi Iwashita, Kochi University of Technology,

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Th1A.20

Neural-Network-Based MDG and Optical SNR Estimation in SDM Transmission

Presenter: Ruby Bravo Ospina , *University of Campinas*

We propose a neural network model for MDG and optical SNR estimation in SDM transmission. We show that the proposed neural-network-based solution estimates MDG and SNR with high accuracy and low complexity from features extracted after DSP.

Authors:Ruby Bravo Ospina, University of Campinas / Menno van den Hout, Eindhoven University of Technology / Sjoerd van der Heide, Eindhoven University of Technology / Chigo Okonkwo, Eindhoven University of Technology / Darli Mello, University of Campinas

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Th1A.21

Simultaneous Reception of ASK-Based AMCC Signals and QPSK Signals With Single Coherent Receiver

Presenter: Ryo Igarashi , *NTT Corporation*

An AMCC signal extraction method for a single coherent receiver is proposed. Experiments demonstrate the successful decoding of a 25 Gbps QPSK-signal and 128 kbps AMCC-signal with the penalty of less than 0.1 dB.

Authors:Ryo Igarashi, NTT Corporation / Ryo Koma, NTT Corporation / Kazutaka Hara, NTT Corporation / Kazuaki Honda, NTT Corporation / Jun-ichi Kani, NTT Corporation / Tomoaki Yoshida, NTT Corporation

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Th1A.22

Optimizing Coherent Integrated Photonic Neural Networks Under Random Uncertainties

Presenter: Sanmitra Banerjee , *Duke University*

We propose an optimization method to improve power efficiency and robustness in silicon-photonic-based coherent integrated photonic neural networks. Our method reduces the network power consumption by 15.3% and the accuracy loss under uncertainties by 16.1%.

Authors:Sanmitra Banerjee, Duke University / Mahdi Nikdast, Colorado State University / Krishnendu Chakrabarty, Duke University

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Th1A.23

Sub-Wavelength Gratings Assisted Ridge Waveguide Surface Couplers on Lithium Niobate Thin Film

Presenter: Sipan Yang , *Shanghai Jiao Tong University*

A thin-film lithium niobate ridge-waveguide grating coupler integrated with waveguide subwavelength gratings is experimentally demonstrated. An ultra-high coupling efficiency of -5.1 dB/coupler for TE polarization and over 90 nm 3-dB optical bandwidth are achieved.

Authors:Sipan Yang, Shanghai Jiao Tong University / Yaqian Li, Shanghai Jiao Tong University / Jinbin Xu, Shanghai Jiao Tong University / Liying Wu, Shanghai Jiao Tong University / Xueling Quan, Shanghai Jiao Tong University / Xiulan Cheng, Shanghai Jiao Tong University

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Th1A.24

Semi-Supervised Anomaly Detection With Imbalanced Data for Failure Detection in Optical Networks

Presenter: Songlin Liu , *Beijing University of Posts and Telecomm*

We proposed an autoencoder-based anomaly-detection for optical failure detection with imbalanced data (<3%), which identifies implicit failure and achieves detection accuracy of 96.8% and F1 value of 0.9224.

Authors:Songlin Liu, Beijing University of Posts and Telecomm / Danshi Wang, Beijing University of Posts and Telecomm / Chunyu Zhang, Beijing University of Posts and Telecomm / Lingling Wang, Beijing University of Posts and Telecomm / Min Zhang, Beijing University of Posts and Telecomm

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Th1A.25

Clock Recovery Performance on Probabilistically-Shaped Transmissions

Presenter: Tiago Sutili , *CPQD*

Performance comparison of timing recovery techniques in a probabilistically-shaped 64QAM system is presented based on simulations and experiments. Results show that the ones relying on dynamic equalizers stand for all cases while Gardner-based do not.

Authors:André Souza, CPQD / José Hélio Cruz Júnior, CPQD / Tiago Sutili, CPQD / Rafael Figueiredo, CPQD

Th1A.26

Vehicle Run-off-Road Event Automatic Detection by Fiber Sensing Technology

Presenter: Tingfeng Li , *Rutgers University*

We demonstrate a new application of fiber-optic-sensing and machine learning techniques for vehicle run-off-road events detection to enhance roadway safety and efficiency. The proposed approach achieves high accuracy in a testbed under various experimental conditions.

Authors:Tingfeng Li, Rutgers University / Yuheng Chen, NEC Laboratories America, Inc. / Ming-Fang Huang, NEC Laboratories America, Inc. / Shaobo Han, NEC Laboratories America, Inc. / Ting Wang, NEC Laboratories America, Inc.

Th1A.27

Low-Complexity Nonlinearity Compensation for Short-Reach IM/DD Systems Using PAM

Presenter: Tom Wettlin , *Kiel University*

We investigate the performance of non-regular PAM8 constellations and introduce a novel non-uniformly quantized equalizer to improve nonlinearity compensation in 70 GBd PAM8 back-to-back and 1 km SSMF transmission without additional complexity.

Authors:Tom Wettlin, Kiel University / Talha Rahman, Huawei Technologies / Stefano Calabro, Huawei Technologies / Jinlong Wei, Huawei Technologies / Md Sabbir-Bin Hossain, Huawei Technologies / Nebojsa Stojanovic, Huawei Technologies / Stephan Pachnicke, Kiel University

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Th1A.28

Generalization Properties of Machine Learning-Based Raman Models

Presenter: Uiara de Moura , *Danmarks Tekniske Universitet*

We investigate the generalization capabilities of neural network-based Raman amplifier models. The new proposed model architecture, including fiber parameters as inputs, can predict Raman gains of fiber types unseen during training, unlike previous fiber-specific models.

Authors:Uiara de Moura, Danmarks Tekniske Universitet / Darko Zibar, Danmarks Tekniske Universitet / Margareth Rosa Brusin, Polito / Andrea Carena, Polito / Francesco Da Ros, Danmarks Tekniske Universitet

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Th1A.29

A Sum-Difference Microring Filter for Lossless Bandwidth Tuning

Presenter: Yang Ren , *University of Alberta*

We propose a general variable-bandwidth filter for lossless bandwidth tuning based on the sum-difference microring architecture. We demonstrate a 4th-order filter in SOI, achieving ~5 folds increase in bandwidth without extra insertion loss or degradation in filter shape.

Authors:Yang Ren, University of Alberta / Zhiping Jiang, Huawei Canada Research Centre / Vien Van, University of Alberta

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Th1A.3

MDM Transmission of 3-D CAP Over 4.1-km Ring-Core Fiber in Passive Optical Networks

Presenter: Min Yang , *Huazhong University of Science and Techn*

We experimentally demonstrate mode-division multiplexing (MDM) passive optical network (PON) based on three-dimensional (3-D) carrier-less amplitude/phase modulation (CAP) architecture, using two orbital angular momentum (OAM) modes for six users in the downstream transmission.

Authors:Min Yang, Huazhong University of Science and Techn / Lulu Wang, Huazhong University of Science and Techn / Hongya Wang, Huazhong University of Science and Techn / Lei Shen, Yangtze Optical Fibre and Cable Joint Stock Limited Company / Lei Zhang, Yangtze Optical Fibre and Cable Joint Stock Limited Company / Jie Luo, Yangtze Optical Fibre and Cable Joint Stock Limited Company / Jian Wang, Huazhong University of Science and Techn

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Th1A.30

Neural-Network-Based Nonlinearity Equalizer for 128 GBaud Coherent Transcievers

Presenter: Vladislav Neskorniuk , *Nokia Bell Labs*

We propose an efficient neural-network-based equalization jointly compensating fiber and transceiver nonlinearities for high-symbol-rate coherent short-reach links. Providing about 0.9dB extra SNR gain, it allows achieving experimentally the record single-channel 1.48Tbps net rate over 240km G.652 fiber.

Authors:Vladislav Neskorniuk, Nokia Bell Labs / Fred Buchali, Nokia Bell Labs / Vinod Bajaj, Nokia Bell Labs / Sergei K Turitsyn, Aston University / Jaroslaw Prilepsky, Aston University / Vahid Aref, Nokia Bell Labs

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Th1A.31

Fabrication-Tolerant Polarization Rotator-Splitter Based on Silicon Nitride Platform

Presenter: Xiangyang Dai , *Wuhan National Laboratory*

We realize a polarization rotator-splitter (PRS) based on the silicon nitride platform. The fabricated PRS has the polarization extinction ratio of over 17 dB and on-chip loss of around 1.5 dB across the C-band.

Authors:Xiangyang Dai, Wuhan National Laboratory / Qiaoyin Lu, Wuhan National Laboratory / Weihua Guo, Wuhan National Laboratory

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Th1A.32

Large Dynamic Range Microwave Photonic Phase Shifter Based on Multi-Order Sidebands Optical Spectrum Vector Process Technique

Presenter: yunping bai , *Beijing University of Posts and Telecom*

A novel linearized microwave photonic phase shifter (MPPS) with high power efficiency is proposed and experimentally demonstrated. In the experiment, the 14-dB and 24-dB improvement are realized in the gain and dynamic range respectively.

Authors:yunping bai, Beijing University of Posts and Telecom / Xiyao Song, Beijing University of Posts and Telecom / Zhennan Zheng, Beijing University of Posts and Telecom / Zhonghan Su, Beijing University of Posts and Telecom / Hao Zhang, Beijing University of Posts and Telecom / Xinlu Gao, Beijing University of Posts and Telecom / Shanguo Huang, Beijing University of Posts and Telecom

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Th1A.33

Mach-Zehnder Interferometer Based Endlessly Adaptive Polarization Controller on Silicon-Photonic Platform

Presenter: Xuefeng Wang , *Huazhong University of Sci & Technol*

We experimentally demonstrated an endlessly adaptive polarization controller based on a Mach-Zehnder Interferometer on the Silicon photonic integrated circuit. A polarization tracking speed up to hundreds of rad/s was achieved for the self-coherent communication system.

Authors:Xuefeng Wang, Huazhong University of Sci & Technol / Yifan Zeng, Huazhong University of Sci & Technol / Ruolin Liao, Huazhong University of Sci & Technol / Can Zhao, Huazhong University of Sci & Technol / Hao Wu, Huazhong University of Sci & Technol / Ming Tang, Huazhong University of Sci & Technol

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Th1A.34

Design Optimization of Uncoupled Six-Core Fibers in Standard Cladding Diameter Using Artificial Intelligence

Presenter: Xun Mu , *UCL*

We report on ultra-wide-band and long-haul compatible 125 um six-core trench-assisted fiber designs. The AI-optimization process considers crosstalk, effective area, and bandwidth. We show that homogeneous cores can lead to low complexity yet high capacity fiber.

Authors:Xun Mu, UCL / Filipe Ferreira, UCL / Alessandro Ottino, UCL / Georgios Zervas, UCL

Th1A.35

SOA-Based Scintillation-Suppressed MLPolSK Detection in FSO Communications

Presenter: YAN-QING HONG , *Yonsei University*

This paper proposes SOA-Based scintillation-suppressed MLPolSK detection in FSO communications. Polarization-independent SOA is applied to mitigate the scintillation effect, and polarization-dependent SOA is used to transform SOPs into intensity. 8LPolSK was effectively detected in experiment.

Authors:YAN-QING HONG, Yonsei University / Sang-Kook Han, Yonsei University

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Th1A.36

Demonstration of Channel-Predictable Free Space Optical Communication System Using Machine Learning

Presenter: Song Song , *Northeastern University*

This paper aims to uncover the predictability of Free Space Optical (FSO) channel. A channel-predictable MISO FSO communication system using machine learning is proposed and experimentally demonstrated through a simulated channel from real-world meteorological dataset.

Authors:Song Song, Northeastern University / Yejun Liu, CQUPT / Tianming Xu, Northeastern University / Shasha Liao, CQUPT / Lei Guo, CQUPT

Th1A.37

Low-Loss Three-Dimensional Fan-in/Fan-out Devices for Multi-Core Fiber Integration

Presenter: Yi-Chun Ling , *University of California, Davis*

We demonstrate a 3D fan-in/fan-out device for multi-core fiber integration fabricated by ultrafast laser inscription using an automatic 3D waveguide routing algorithm. The low propagation loss of 0.3 dB/cm and 0.16 dB/cm have been achieved for two types of glasses.

Authors:Yi-Chun Ling, University of California, Davis / Shuyun Yuan, University of California, Davis / S. J. Ben Yoo, University of California, Davis

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Th1A.38

RF Phase Controlled True Time Delay

Presenter: Xie Xiangzhi , *Beijing Univ of Posts & Telecom*

The proposed true time delay (TTD) can be continuously tuned by changing the phase of sinusoidal. Adjustable delay range of 11ns for RF pulse with bandwidth of 1.32GHz is experimentally demonstrated.

Authors:Xie Xiangzhi, Beijing Univ of Posts & Telecom / Jilong Li, Beijing Univ of Posts & Telecom / FEIFEI YIN, Beijing Univ of Posts & Telecom / Kun Xu, Beijing Univ of Posts & Telecom / Yitang Dai, Beijing Univ of Posts & Telecom

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Th1A.39

C-Band Direct Detection Transmission of 90Gbaud PAM-6/4 Over 10/20km SSMF With 2-Tap Pre-Equalization and Skew-Enabled VSB Shaping

Presenter: Yixiao Zhu , *Shanghai Jiao Tong University*

90Gbaud Nyquist PAM-6/4 are experimentally transmitted over 10/20km SSMF with direct detection at C-band. Bandwidth limitation is compensated by 2-tap pre-equalization, and dispersion-induced power fading is overcome by introducing differential time skew.

Authors:Yixiao Zhu, Shanghai Jiao Tong University / Lei Zhang, Peking University / Xiansong Fang, Peking University / Fan Zhang, Peking University / Weisheng Hu, Shanghai Jiao Tong University

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Th1A.4

Crosstalk Statistical Distributions in Multicore Fibers Under Different Deployment Conditions

Presenter: Ming-Jun Li , *Corning Inc*

Crosstalk statistical distributions of multicore fiber are studied theoretically and experimentally. It is shown that a crosstalk distribution can be characterized with different types of perturbations to yield the same result.

Authors:Vladimir Nazarov, Corning Scientific Center / Sergey Kuchinsky, Corning Scientific Center / Aramais Zakharian, Corning Inc / Ming-Jun Li, Corning Inc

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Th1A.40

Slicing and Sliding Algorithm Compatible With PAM/SCM Signal for Chirp and Dispersion Induced Distortion Compensation in DML-Based DD System

Presenter: Yixiao Zhu , *Shanghai Jiao Tong University*

We propose a slicing and sliding algorithm to mitigate the distortion caused by DML chirp and fiber dispersion. 80Gb/s PAM-4 and SCM-16QAM signal C-band 10km transmission are experimentally demonstrated with >2dB ROP sensitivity improvement.

Authors:Yixiao Zhu, Shanghai Jiao Tong University / Xin Miao, Shanghai Jiao Tong University / qi wu, Shanghai Jiao Tong University / Weisheng Hu, Shanghai Jiao Tong University

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Th1A.41

Experimental Assessment of an Ultra-Wide Band (O to L) Polymer Thermo-Optic Switch Matrix

Presenter: Yu Wang , *IPI-ECO Research Institute, Eindhoven University of Technology*

An ultra-wide band (O to L) 4×4 polymer switch matrix is experimentally demonstrated. Results show <0.6dB polarization-dependent loss, >36dB switching ratio, <6.5dB fiber-to-fiber loss, and error-free operation with <0.15dB power penalty at 10Gb/s and 50Gb/s.

Authors:Yu Wang, IPI-ECO Research Institute, Eindhoven University of Technology / Netsanet Tessema, IPI-ECO Research Institute, Eindhoven University of Technology / Hyun-Do Jung, Electronics and Telecommunications Research Institute (ETRI) / Jang-Uk Shin, Electronics and Telecommunications Research Institute (ETRI) / Nicola Calabretta, IPI-ECO Research Institute, Eindhoven University of Technology

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Th1A.42

A Novel Method for Distributed Phase Birefringence Measurement Based on Chirped Pulse φ-OTDR.

Presenter: Yuan Wang , *University of Ottawa*

A novel method for phase birefringence measurement is theoretically analyzed and experimentally demonstrated. By using the chirped pulses, the local birefringence could be directly measured based on local time delays of reflected Rayleigh traces between slow and fast axes. The birefringence measurement resolution is up to 2×10^{-9}.

Authors:Yuan Wang, University of Ottawa / Liang Chen, University of Ottawa / Xiaoyi Bao, University of Ottawa

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Th1A.43

Mitigation of Wave-Induced Packet Loss for Water-air Optical Wireless Communication by a Tracking System

Presenter: Yujie DI , *The Chinese University of Hong Kong*

We experimentally demonstrated a reliable water-air optical wireless link with a fast-tracking system to combat the wave-induced beam deflection. A maximum packet loss rate reduction from 6.04% to 0.63% is achieved for a 50-Mbps signal.

Authors:Yujie DI, The Chinese University of Hong Kong / Yingjie Shao, The Chinese University of Hong Kong / Lian-Kuan Chen, The Chinese University of Hong Kong

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Th1A.44

Low-Complexity, Loop-Unrolled Decision-Feedback Equalizer for IM/DD System Using PAM Formats

Presenter: Yukui Yu , *KAIST, Korea*

We propose and demonstrate a low-complexity, loop-unrolled DFE for band-limited IM/DD system. The proposed equalizer nearly doubles the maximum achievable data-rate of DFE for PAM-4 signal, but requires complexity similar to that of NRZ DFE.

Authors:Yukui Yu, KAIST, Korea / Yi Che, KAIST, Korea / Tianwai Bo, KAIST, Korea / Daeho Kim, KAIST, Korea / Hoon Kim, KAIST, Korea

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Th1A.46

Monolithically Integrated Silicon Nitride Platform

Presenter: Yusheng Bian , *GLOBALFOUNDRIES*

A comprehensive set of SiN building blocks was demonstrated on a monolithic SiPh platform. Low-loss SiN waveguides (<0.35dB/cm), Si-SiN transitions (0.026dB), efficient polarization splitters/rotators, and compact ring WDM filters were realized at O-band.

Authors:Yusheng Bian, GLOBALFOUNDRIES / Colleen Meagher, GLOBALFOUNDRIES / Karen Nummy, GLOBALFOUNDRIES / Sujith Chandran, Khalifa University / Wonsuk Lee, GLOBALFOUNDRIES / Abdelsalam Aboketaf, GLOBALFOUNDRIES / Danhao Ma, GLOBALFOUNDRIES / Ryan Sporer, GLOBALFOUNDRIES / Michal Rakowski, GLOBALFOUNDRIES / Nuh Yuksek, GLOBALFOUNDRIES / Monica Esopi, GLOBALFOUNDRIES / Bo Peng, GLOBALFOUNDRIES / Yangyang Liu, GLOBALFOUNDRIES / Abu Thomas, GLOBALFOUNDRIES / Tymon Barwicz, IBM / Takako Hirokawa, GLOBALFOUNDRIES / Javier Ayala, GLOBALFOUNDRIES / Asli Sahin, GLOBALFOUNDRIES / Andy Stricker, GLOBALFOUNDRIES / Subramanian Krishnamurthy, GLOBALFOUNDRIES / Shuren Hu, GLOBALFOUNDRIES / Zoey Sowinski, GLOBALFOUNDRIES / Kate Mclean, GLOBALFOUNDRIES / Louis Medina, GLOBALFOUNDRIES / Kevin Dezfulian, GLOBALFOUNDRIES / Michelle Zhang, GLOBALFOUNDRIES / Mona Nafari, GLOBALFOUNDRIES / Zhuoqiang Jia, GLOBALFOUNDRIES / Kaushikee Mishra, GLOBALFOUNDRIES / Asif Chowdhury, GLOBALFOUNDRIES / Jaime Viegas, Khalifa University / Rod Augur, GLOBALFOUNDRIES / Dave Riggs, GLOBALFOUNDRIES / Luke Lee, GLOBALFOUNDRIES / Wenhe Lin, GLOBALFOUNDRIES / Ajey Jacob, GLOBALFOUNDRIES / Vikas Gupta, GLOBALFOUNDRIES / Anthony Yu, GLOBALFOUNDRIES / Ken Giewont, GLOBALFOUNDRIES / Ted Letavic, GLOBALFOUNDRIES / John Pellerin, GLOBALFOUNDRIES

Th1A.47

Towards Low Computational Complexity for Neural Network-Based Equalization in PAM4 Short-Reach Direct Detection Systems by Multi-Symbol Prediction

Presenter: Zhaopeng Xu , *University of Melbourne*

We propose NN-based multi-symbol equalization for a 50-Gb/s PAM4 direct-detection link which significantly reduces computational complexity without sacrificing BER performance of conventional single-output NNs. Complexity reduction of 42.7% is achieved when 8 outputs are selected.

Authors:Zhaopeng Xu, University of Melbourne / Chuanbowen Sun, University of Melbourne / Shuangyu Dong, University of Melbourne / Jonathan Manton, University of Melbourne / William Shieh, University of Melbourne

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Th1A.48

Computing-Aware Proactive Network Reconfiguration for Optical Networks Interconnected Edge Computing System

Presenter: Zhekang Li , *Beijing University of Posts and Telecommunications*

This paper demonstrates a proactively reconfigured edge network that can adaptively configure IP topology for dynamic service demand. Simulation result show the average utilization has improved from 32.50% to 68.98% compared traditional static network.

Authors:Zhekang Li, Beijing University of Posts and Telecommunications / Rentao Gu, Beijing University of Posts and Telecommunications / Linna Wang, Beijing University of Posts and Telecommunications / Yuefeng Ji, Beijing University of Posts and Telecommunications

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Th1A.49

Microbending Loss Properties of Different Fiber Designs

Presenter: Zoltan Varallyay , *Furukawa Electric Institute of Tech Ltd.*

Simulation model to calculate the micro-bending loss, based on the coupled mode theory with additional empirical parameters is fitted to our measurement data. Relation between micro-bending loss, effective core area and design parameters are investigated.

Authors:Zoltan Varallyay, Furukawa Electric Institute of Tech Ltd. / Tamás Mihálffy, Furukawa Electric Institute of Tech Ltd. / Sándor Bilicz, Budapest University of Technology and Economics / Gábor Varga, Furukawa Electric Institute of Tech Ltd. / Kazunori Mukasa, Furukawa Electric Co. Ltd.

Th1A.5

Security Analysis of Quantum Noise Stream Cipher Under Fast Correlation Attack

Presenter: mingrui zhang , *Beijing Univ. of Posts and Telecom.*

We conduct an experiment of security analysis on 300km QAM/QNSC transmission under fast correlation attack. Noise masking model and hypothesis testing theory are adopted. Experiment results provide several solutions to achieve secure transmission in QAM/QNSC.

Authors:mingrui zhang, Beijing Univ. of Posts and Telecom. / Yajie Li, Beijing Univ. of Posts and Telecom. / Haokun Song, Beijing Univ. of Posts and Telecom. / Bo Wang, Beijing Univ. of Posts and Telecom. / Yongli Zhao, Beijing Univ. of Posts and Telecom. / Jie Zhang, Beijing Univ. of Posts and Telecom.

Th1A.50

2-bit Delta-Sigma Modulated 32-QAM OFDM Based Dual-Wavelength Digital RoF Link

Presenter: Zu-Kai Weng , *Waseda University*

A dual-wavelength digital RoF link was experimentally demonstrated by OSR-reduced 2-bit delta-sigma modulated 32-QAM OFDM. The optically generated data was transmitted over 25-km SMF at receiving power of -9.9 dBm.

Authors:Zu-Kai Weng, Waseda University / Atsushi Kanno, National Institute of Information and Communications Technology / Tetsuya Kawanishi, Waseda University

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Th1A.6

Microwave Frequency Comb Generation Based on Active Mode-Locking of a Polarization-Multiplexed Dual Loop Optoelectronic Oscillator

Presenter: Yan Li , *Beijing Jiaotong University*

A photonics-assisted microwave frequency comb (MFC) generator based on a polarization-multiplexed dual loop optoelectronic oscillator (OEO) is proposed. Experimental results demonstrate the generated MFC has adjustable comb interval and low phase noise.

Authors:Yan Li, Beijing Jiaotong University / Muguang Wang, Beijing Jiaotong University / Jing Zhang, Beijing Jiaotong University / Hongqian Mu, Beijing Jiaotong University / Chuncan Wang, Beijing Jiaotong University / Fengping Yan, Beijing Jiaotong University

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Th1A.7

A Novel Linearization Method for Optical Transmitters Based on Directly-Modulated Lasers

Presenter: Nikos Bamiedakis , *University of Cambridge*

A new practical method to correct the non-linearity of directly-modulated lasers is presented and an experimental proof-of-principle demonstration is reported. High-quality NRZ transmission at 16 Gb/s is achieved using a VCSEL specified for 10 Gb/s.

Authors:Nikos Bamiedakis, University of Cambridge / David Cunningham, University of Cambridge / Richard Penty, University of Cambridge

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Th1A.8

Wavelength Resources Management and Switching of Active Entanglement Distribution Circuits in Optical Networks

Presenter: obada alia , *High Performance Network Group*

We provide a formal definition of the entangled wavelength-pairs allocation problem using PDDL paired with a Fast-Forward planner and switching algorithm to optimize the resources of entanglement distribution circuits in optical networks.

Authors:obada alia, High Performance Network Group / Rodrigo Tessinari, High Performance Network Group / Emilio Hugues-Salas, High Performance Network Group / George Kanellos, High Performance Network Group / Reza Nejabati, High Performance Network Group / Dimitra Simeonidou, High Performance Network Group

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Th1A.9

High-Speed Transmissions With Direct-Modulation Room-Temperature Semiconductor Lasers Emitting in the Transparency Window Around 4 µm

Presenter: Olivier Spitz , *Télécom Paris*

We experimentally realize a free-space transmission over one meter with room-temperature quantum cascade lasers and interband cascade lasers. With direct electrical modulation and raw analysis, the data-rate of the real-time transmission outperforms similar reported schemes.

Authors:Olivier Spitz, Télécom Paris / Lauréline Durupt, Télécom Paris / Pierre Didier, Télécom Paris / Daniel Diaz-Thomas, Université de Montpellier / Laurent Cerutti, Université de Montpellier / Alexei Baranov, Université de Montpellier / Mathieu Carras, mirSense / Frédéric Grillot, Télécom Paris

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5:00 - 7:00 Pacific Time (US & Canada) (UTC - 07:00)

Th2A

Symposia: Quantum Information Science and Technology (QIST) in the Context of Optical Communications (Quantum Key Distribution)

Presider: Dominic O'Brien

Th2A.1

Quantum Key Distribution (QKD) and the Quantum Internet: the Challenges Facing This New Technology

Invited

Presenter: Andrew Lord , *BT*

We describe the status of Quantum Key Distribution and highlight the developments required for this technology and describing a full QKD network. We set out the major differences between QKD and the Quantum Internet

Authors:Andrew Lord, BT / Catherine White, BT / Emilio Hugues Salas, BT

Th2A.2

Secure Quantum Communications Beyond the Repeaterless Secret Key Capacity: Overview and Recent Progress

Invited

Presenter: Marco Lucamarini , *University of York*

Quantum repeaters are the holy grail of quantum communications, but their implementation remains challenging. In 2018, however, a new practical scheme capable of repeating a quantum signal was introduced with the name of 'twin-field quantum key distribution'. In this paper, I will describe the recent progress on the implementation of this scheme.

Authors:Marco Lucamarini, University of York

Th2A.3

Long Distance Quantum Key Distribution

Invited

Presenter: Qiang Zhang , *University of Science and Technology of China*

We shall present the experiemtnal progroess in our group, including twin field QKD in 511 deployed long haul fiber, measurement device independent QKD through 10 km urban air and test
of PQC authorized QKD in a metropolitan network.

Authors:Qiang Zhang, University of Science and Technology of China

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Th2A.4

Madrid Quantum Communication Infrastructure: a Testbed for Assessing QKD Technologies Into Real Production Networks

Invited

Presenter: Diego Lopez , *Telefónica I+D*

Using new Quantum Key Distribution systems paired with modern networking paradigms, we demonstrate a high technology readiness level of QKD installing the network in production facilities and running relevant use cases.

Authors:Diego Lopez, Telefónica I+D

7:00 - 8:00 Pacific Time (US & Canada) (UTC - 07:00)

SF11
Exhibit Hall Event - Industry Program: 5G and Network Slicing

SF12
Exhibit Hall Event - Industry Program: OpenROADM Demo Description and Update

7:30 - 9:30 Pacific Time (US & Canada) (UTC - 07:00)

Th3A
Symposia: Quantum Information Science and Technology (QIST) in the Context of Optical Communications (Quantum Networks and Applications)
Presider: Eleni Diamanti

Th3A.1
Quantum Machine Learning Using Photonic Systems
Invited

Presenter: Philip Walther , *University of Vienna*

This talk covers recent experiments using integrated nanophotonic processors for reinforcement quantum learning, where agents interact with environments by exchanging signals via a communication channel, and homomorphically-encrypted quantum walks for secure quantum computing.

Authors:Philip Walther, University of Vienna

Th3A.2

Fiber Resonators Coupled to Trapped Ions: a Route to Quantum Networks

Invited

Presenter: Tracy Northup , *Leopold-Franzens Universitat Innsbruck*

Entanglement-based quantum networks require interfaces between photonic and matter-based quantum bits. I will discuss the advantages and challenges of constructing quantum interfaces based on fiber resonators between photons and trapped ions.

Authors:Tracy Northup, Leopold-Franzens Universitat Innsbruck

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Th3A.3

Quantum Networks Beyond Point-to-Point Configurations

Invited

Presenter: Antonio Acin , *ICFO -Institut de Ciencies Fotoniques*

We present different applications that make use of the possibilities offered by networks with respect to standard point-to-point direct transmission. The obtained results range from questions in the foundations of quantum physics, to the design of quantum cryptography implementations.

Authors:Antonio Acin, ICFO -Institut de Ciencies Fotoniques

Th3A.4

Entangled Sensor Networks Empowered by Machine Learning

Invited

Presenter: Zheshen Zhang , *University of Arizona*

We propose and experimentally demonstrate a reconfigurable radio-frequency photonic sensor network based on continuous-variable multipartite entanglement. We further show that the entangled sensor network can be trained to undertake quantum-enhanced data classification tasks.

Authors:Yi Xia, University of Arizona / Wei Li, University of Arizona / William Clark, General Dynamics Mission Systems / Darlene Hart, General Dynamics Mission Systems / Quntao Zhuang, University of Arizona / Zheshen Zhang, University of Arizona

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7:30 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE4

Exhibit Hall Event - OFC Employer Showcase/ Career Fair

8:00 - 9:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE21
Special Event - IEEE Future Networks INGR Optics Roadmap

10:00 - 10:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC19
Exhibit Hall Event - Technology Showcase: Fiber Innovations: Past, Present, and the Shape of the Future

10:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

10:30 - 11:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC20
Exhibit Hall Event - Technology Showcase: Nokia 400G Everywhere

10:30 - 11:30 Pacific Time (US & Canada) (UTC - 07:00)

SF18
Exhibit Hall Event - 5G Optics - Mobile Optical Solutions and Standards

10:30 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

MW5
Exhibit Hall Event - Market Watch: Next-gen Access Networks (including Coherent Technology as an Alternative to Access Optics)

11:00 - 11:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE16
Exhibit Hall Event - OSA Booth, Tech Talk: Optical Fiber Sensors Commercialization: Present Status and Future Opportunities and Trends

TSC21
Exhibit Hall Event - Technology Showcase: 3D Sensing Beyond Gesture Recognition

11:00 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

SF13
Exhibit Hall Event - Industry Program: Cloud Network Evolution Bandwidth Drivers

11:30 - 12:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC22
Exhibit Hall Event - Technology Showcase: 224 Gbps Data Rates: The (Bumpy) Road Ahead

12:00 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

SpE17
Exhibit Hall Event - OSA Booth, Tech Talk: Silicon-photonic-based Short-reach Pluggables

12:30 - 14:00 Pacific Time (US & Canada) (UTC - 07:00)

MW6
Exhibit Hall Event - Market Watch: Evolving Photonics Integration and Packaging

12:30 - 14:30 Pacific Time (US & Canada) (UTC - 07:00)

Th4A

Advanced Photonic Integration and Co-packaging

Presider: Di Liang

Th4A.1

Polymer Waveguide-Coupled Co-Packaged Silicon Photonics-die Embedded Package Substrate

Invited

Presenter: Takeru Amano , *Natl Inst of Adv Industrial Sci & Tech*

We propose a next generation co-packaged substrate using Si photonics dies, a polymer optical waveguide, and a optical connector to achieve beyond 10 Tb/s and WDM optical links. The two micro-mirrors and polymer waveguides were integrated, and their optical characteristics were evaluated.

Authors:Takeru Amano, Natl Inst of Adv Industrial Sci & Tech / Akihiro Noriki, Natl Inst of Adv Industrial Sci & Tech / Isao Tamai, PETRA / Yasuhiro Ibusuki, PETRA / Akio Ukita, PETRA / Satoshi Suda, Natl Inst of Adv Industrial Sci & Tech / Takayuki Kurosu, Natl Inst of Adv Industrial Sci & Tech / Koichi Takemura, PETRA / Tsuyoshi Aoki, PETRA / Daisuke Shimura, PETRA / Yosuke Onawa, PETRA / Hiroki Yaegashi, PETRA

Th4A.2

8 Tbps Co-Packaged FPGA and Silicon Photonics Optical IO

Presenter: Kaveh Hosseini , *Intel*

The first 8 Tbps co-packaged FPGA with Silicon-Photonics IO is presented paving the way for co-packaged compute and optical-IO. The Multi-Chip Package integrates Stratix® 10 FPGA with up to five optical IO chiplets.

Authors:Kaveh Hosseini, Intel / Edwin Kok, Intel / Sergey Shumarayev, Intel / Chia-Pin Chiu, Intel / Arnab Sarkar, Intel / Asako Toda, Intel / Yanjing Ke, Intel / Allen Chan, Intel / Daniel Jeong, Ayar Labs / Mason Zhang, Ayar Labs / Sangeeta Raman, Intel / Thungoc Tran, Intel / Kumar Abhishek Singh, Intel / Pavan Bhargava, Ayar Labs / Chong Zhang, Ayar Labs / Haiwei Lu, Ayar Labs / Ravi Mahajan, Intel / Xiaoqian Li, Intel / Nitin Deshpande, Intel / Conor O'Keeffe, Intel / Tim Tri Hoang, Intel / Uma Krishnamoorthy, Ayar Labs / Chen Sun, Ayar Labs / Roy Meade, Ayar Labs / Vladimir Stojanovic, Ayar Labs / Mark Wade, Ayar Labs

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Th4A.3

3.2T/6.4T CWDM ROSA for Co-Packaged Optic Transceiver

Presenter: Li Zhang , *II-VI Corporation*

A compact 64-channel (16x CWDM4) ROSA is demonstrated. The ROSA core with InP PD array vertically aligned to PLC chip provides a new solution to 3.2T/6.4T co-packaged optic transceivers. The performance is verified to be comparable to pluggable transceivers.

Authors:Li Zhang, II-VI Corporation / Yao Sun, II-VI Corporation / Xiaoqiong Qin, II-VI Corporation / Liangpeng Guan, II-VI Corporation / Caixia Zhu, II-VI Corporation / Yinhe Peng, II-VI Corporation / Jianhu Wei, II-VI Corporation / Shuchao Lv, II-VI Corporation / Yunyan Sun, II-VI Corporation / Jinlong Shang, II-VI Corporation / Jieming Xu, II-VI Corporation / Xiongwen Chen, II-VI Corporation / Wei Si, II-VI Corporation / Shanshan Zeng, II-VI Corporation

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Th4A.4

3D-Integrated Multichip Module Transceiver for Terabit-Scale DWDM Interconnects

Presenter: Stuart Daudlin , *Columbia University*

We present the architecture and assembly of a compact, 3D-integrated CMOS-silicon photonic transceiver for DWDM interconnects. The transceiver interleaves 64 parallel wavelength channels enabling energy efficient scaling of multi-Tbps/mm^2 bandwidth densities for future co-packaged chipsets.

Authors:Stuart Daudlin, Columbia University / Anthony Rizzo, Columbia University / Nathan Abrams, Columbia University / Sunwoo Lee, Cornell University / Devesh Khilwani, Cornell University / Vaishnavi Murthy, Columbia University / James Robinson, Columbia University / Terence Collier, CVI / Alyosha Molnar, Cornell University / Keren Bergman, Columbia University

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Th4A.5

Kerr Comb-Driven Silicon Photonic Transmitter

Presenter: Anthony Rizzo , *Columbia University*

We demonstrate the first on-chip silicon photonic transmitter using a Kerr frequency comb source for massive wavelength parallelism. The architecture is scalable to hundreds of wavelength channels, paving the way for multi-Tb/s photonic interconnects.

Authors:Anthony Rizzo, Columbia University / Asher Novick, Columbia University / Vignesh Gopal, Columbia University / Stuart Daudlin, Columbia University / Vaishnavi Murthy, Columbia University / Hao Yang, Columbia University / Qixiang Cheng, University of Cambridge / Yoshitomo Okawachi, Columbia University / Bok Young Kim, Columbia University / Xingchen Ji, Columbia University / Michael Fanto, Air Force Research Laboratory / Michal Lipson, Columbia University / Alexander Gaeta, Columbia University / Keren Bergman, Columbia University

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Th4B

Filtering and Active Stabilization Devices

Presider: Cheryl Sorace-Agaskar

Th4B.1

Integrated SBS Devices

Invited

Presenter: Benjamin Eggleton , *University of Sydney*

Stimulated Brillouin Scattering can be harnessed for advanced photonic signal processing of digital and anlogue signals in chip-based devices. My talk reviews recent progress highligthing major performance improvements and steps towards hybrid integration.

Authors:Benjamin Eggleton, University of Sydney

Th4B.2

Self-Similar Ultra-High Q Si_3N_4 Integrated Resonators for Brillouin Laser Linewidth Narrowing and Stabilization

Presenter: KAIKAI LIU , *UC Santa Barbara*

We report an ultra-high Q Si_3N_4 waveguide resonator Brillouin laser stabilized to an identical waveguide resonator to achieve a linewidth of 330 Hz and a record high stability of 6.5×10^{-13} at 8 ms.

Authors:KAIKAI LIU, UC Santa Barbara / grant brodnik, UC Santa Barbara / Mark Harrington, UC Santa Barbara / Andrei Isichenko, UC Santa Barbara / Qiancheng Zhao, UC Santa Barbara / John Dallyn, Northern Arizona University / Ryan Behunin, Northern Arizona University / Paul Morton, Morton Photonics Inc. / Scott Papp, University of Colorado Boulder / Daniel Blumenthal, UC Santa Barbara

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Th4B.3

Arbitrary Dispersion Compensation of Periodic Waveforms Using on-Chip Discrete Phase Filters

Presenter: Saket Kaushal , *INRS-EMT*

We propose a discrete phase filter design suitable for arbitrary dispersion compensation of periodic waveforms using waveguide Bragg gratings in silicon. Higher-order dispersion compensation (equivalent to 5,000 km long optical fiber) of a 40-GHz picosecond pulse train is experimentally demonstrated using mm-long phase filters.

Authors:Saket Kaushal, INRS-EMT / Jose Azana, INRS-EMT

Th4B.4

Automated Cloning and Lookup Table Generation for Reconfigurable Photonic Integrated Filters

Presenter: Matteo Petrini , *Politecnico di Milano*

We propose a strategy to automatically replicate the spectral response of photonic filters, here applied to coupled microring resonator architectures. This control scheme is exploited to generate Lookup Tables for devices operating in flexible networks.

Authors:Matteo Petrini, Politecnico di Milano / Maziyar Milanizadeh, Politecnico di Milano / Francesco Morichetti, Politecnico di Milano / Andrea Melloni, Politecnico di Milano

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Th4B.5

Silicon Nitride Bus-Coupled Spiral-Ring Resonator for Dual-Mode Locking Temperature Stabilization

Presenter: Qiancheng Zhao , *University of California Santa Barbara*

A Si_3N_4 bus-coupled spiral-ring dual-mode resonator reference cavity, with high extinction ratios for both TE and TM modes, is demonstrated for temperature stabilization. The temperature is stabilized within ± 60 μK variation over 16 hours

Authors:Qiancheng Zhao, University of California Santa Barbara / Mark Harrington, University of California Santa Barbara / Andrei Isichenko, University of California Santa Barbara / Debapam Bose, University of California Santa Barbara / Jiawei Wang, University of California Santa Barbara / KAIKAI LIU, University of California Santa Barbara / Ryan Behunin, Northern Arizona University / Peter Rakich, Yale University / Chad Hoyt, Honeywell Aerospace / Chad Fertig, Honeywell Aerospace / Daniel Blumenthal, University of California Santa Barbara

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Th4B.6

External Modulator-Based Automatic Tuning of Reconfigurable Silicon Photonic 4th-Order APF-Based Pole/Zero Filters

Presenter: Ramy Rady , *Texas A&M*

This paper presents an automatic monitor-based tuning of an APF-based pole/zero optical filter using an external modulator. The proposed algorithm uses a modulator to tune the filter center frequency instead of a tunable laser.

Authors:Ramy Rady, Texas A&M / Gihoon Choo, Apple / Christi Madsen, Texas A&M / Samuel Palermo, Texas A&M / Kamran Entesari, Texas A&M

Th4B.7

Active Compensation of Nonlinear Effects in Silicon Photonic Microring Filters

Presenter: Matteo Petrini , *Politecnico di Milano*

We propose a technique for automated active compensation of nonlinear effects in silicon photonic coupled microring resonator filters. Transmission performances of 200 Gbit/s DP 16-QAM signals up to 20 dBm are evaluated.

Authors:Matteo Petrini, Politecnico di Milano / Maziyar Milanizadeh, Politecnico di Milano / Francesco Morichetti, Politecnico di Milano / Andrea Melloni, Politecnico di Milano

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Th4C

Long-haul and Multiband Systems

Presider: Rui Lin

Th4C.1

Optical Amplifiers for Wideband Optical Transmission Systems

Invited

Presenter: Lutz Rapp , *ADVA*

Exploiting new wavelength bands for data transmission is the most economic step for further increasing the capacity of optical links. Important aspects of the most relevant amplifier technologies supporting this step are discussed.

Authors:Lutz Rapp, ADVA / Michael Eiselt, ADVA

Th4C.2

S, C and Extended L Band Transmission With Doped Fiber and Distributed Raman Amplification

Presenter: Benjamin Puttnam , *National Inst Info & Comm Tech (NICT)*

We transmit 690, near continuous, 25 GHz spaced channels in 138 nm of S, C and extended L-bands over 54 km of standard single-mode fiber. Erbium and Thulium doped-fiber amplifiers with distributed Raman amplification enable a 206.1 Tb/s GMI estimated data-rate.

Authors:Benjamin Puttnam, National Inst Info & Comm Tech (NICT) / Ruben Luis, National Inst Info & Comm Tech (NICT) / Georg Rademacher, National Inst Info & Comm Tech (NICT) / Manuel Mendez-Astudilio, National Inst Info & Comm Tech (NICT) / Yoshinari Awaji, National Inst Info & Comm Tech (NICT) / Hideaki Furukawa, National Inst Info & Comm Tech (NICT)

Th4C.3

Single- vs. Multi-Band Optimized Power Control in C+L WDM 400G Line Systems

Presenter: Elliot London , *Politecnico di Torino*

We propose an optimal strategy for C+L multi-band power control assessing its performance against a single-band one. Via SSFM simulations, we demonstrate that the L-band can be optimized independently.

Authors:Emanuele Virgillito, Politecnico di Torino / Elliot London, Politecnico di Torino / Andrea D'Amico, Politecnico di Torino / Bruno Correia, Politecnico di Torino / Antonio Napoli, Infinera / Vittorio Curri, Politecnico di Torino

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Th4C.4

Techno-Economic Analysis of Multicore Fibers in Submarine Systems

Invited

Presenter: John Downie , *Corning Inc*

We model the application of multicore optical fibers for submarine systems using an approach to estimate relative cost/bit. While multicore fibers may offer higher capacity, achieving lower cost/bit than single core fiber systems remains challenging.

Authors:John Downie, Corning Inc / Xiaojun Liang, Corning Inc / Sergejs Makovejs, Corning Inc

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Th4C.5

9 Tb/s Transmission Using 29 mW Optical Pump Power per EDFA With 1.24 Tb/s/W Power Efficiency Over 15,050 km

Presenter: Jin-Xing Cai , *SubCom*

We transmit 143x32.6 GBd 8D-QPSK signal over 15,050 km with EDFAs consuming 29 mW of 980 nm-pump power. We experimentally achieve record power efficiencies from 6.5 to 1.24 Tb/s/W for transmission distances ranging from 6,020 to 15,050 km respectively.

Authors:Jin-Xing Cai, SubCom / Matt Mazurczyk, SubCom / Govind Vedala, SubCom / Yue Hu, SubCom / Oleg Sinkin, SubCom / Maxim Bolshtyansky, SubCom / Dmitri Foursa, SubCom / Alexei Pilipetskii, SubCom

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Th4D

Short Course - Advanced Direct Detection Techniques

Presider: Liang Zhang

Th4D.1

Orthogonal Circulant Multiplexing Based on the Chirp-Like Polyphase Sequence in Short-Reach IM/DD Systems

Presenter: Zhaoquan Fan , *South China University of Technology*

We propose a novel orthogonal circulant multiplexing technique based on the chirp-like polyphase sequence and show in 115.8-Gbit/s IM/DD experiments with 10-GHz-class devices that this scheme outperforms OFDM, DFT-spread OFDM, OCT-precoded OFDM and OCDM.

Authors:Zhaoquan Fan, South China University of Technology / Jian Zhao, South China University of Technology

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Th4D.2

Generalized Carrier Assisted Differential Detection With Simplified Receiver Structure

Presenter: Honglin Ji , *The University of Melbourne*

We propose the generalized carrier assisted differential detection schemes with reduced hardware complexity, which requires the same number of photodiodes and ADCs as the coherent homodyne counterpart but without the narrow-linewidth local oscillators. The performance of the simplified receiver is evaluated by 60-Gbaud 16-QAM OFDM signals.

Authors:Honglin Ji, The University of Melbourne / Chuanbowen Sun, The University of Melbourne / Ranjith Unnithan, The University of Melbourne / William Shieh, The University of Melbourne

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Th4D.3

Space-Time Diversity Phase Retrieval Receiver

Presenter: Haoshuo Chen , *Nokia Bell Labs*

We enhance the performance of the phase retrieval receiver employing space-time diversity to approach coherent detection's sensitivity limit and experimentally realize >100Gbit/s carrier-less transmission over 55-km SMF.

Authors:Haoshuo Chen, Nokia Bell Labs / Nicolas Fontaine, Nokia Bell Labs / Rene-Jean Essiambre, Nokia Bell Labs / Hanzi Huang, Nokia Bell Labs / Mikael Mazur, Nokia Bell Labs / Roland Ryf, Nokia Bell Labs / David Neilson, Nokia Bell Labs

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Th4D.4

Kramers-Kronig Receiver Combined With Digital Resolution Enhancer

Presenter: Menno van den Hout , *Eindhoven University of Technology*

A Kramers-Kronig receiver with a continuous wave tone added digitally at the transmitter is combined with a digital resolution enhancer to limit the increase in transmitter quantization noise. Performance increase is demonstrated, as well as the ability to reduce the number of bits in the digital-to-analog converter.

Authors:Menno van den Hout, Eindhoven University of Technology / Sjoerd van der Heide, Eindhoven University of Technology / Chigo Okonkwo, Eindhoven University of Technology

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Th4D.5

Advanced Direct Detection Schemes

Tutorial

Presenter: William Shieh , *University of Melbourne*

In this tutorial, we review various advanced direct detection schemes to bridge the gap between conventional direct and coherent detection. We show such schemes may play an important role for future ultrahigh-speed short-reach applications.

Authors:William Shieh, University of Melbourne / Honglin Ji, University of Melbourne

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Th4E
DCI Switching/Interconnect Subsystems

Presider: Ruben Luis

Th4E.1

Clock-Synchronized Clock and Data Recovery to Enable Sub-Nanosecond Optically-Switched Networks

Invited

Presenter: Zhixin Liu , *University College London*

We review the clock-synchronized approach to clock and data recovery, which enables sub-nanosecond switching time in optically switched networks, and explore the impact of factors such as temperature and jitter on performance and scalability.

Authors:Zhixin Liu, University College London / Kari Clark, University College London

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Th4E.2

Clock Synchronized Transmission of 51.2 GBd Optical Packets for Optically Switched Data Center Interconnects

Presenter: Zichuan Zhou , *University College London*

We demonstrate clock-synchronized transmission of 128-byte optical packets at 51.2GBd. We study the impact of reference clock phase noise on the clock phase misalignment and system scalability for high baud rate DC interconnects.

Authors:Zichuan Zhou, University College London / Kari Clark, University College London / Callum Deakin, University College London / Petros Laccotripes, University College London / Zhixin Liu, University College London

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Th4E.3

Experimental Evaluation of Optical Cross-Connects With Flexible Waveband Routing Function for SDM Networks

Presenter: Takuma Kuno , *Nagoya University*

We experimentally evaluate the transmission performance of OXC structures based on flexible-waveband routing. 1600 km, 700 km, and 600 km transmission is demonstrated using 32 Gbaud DP-QPSK, DP-8QAM, and DP-16QAM on 37.5 GHz grid, respectively.

Authors:Takuma Kuno, Nagoya University / Yojiro Mori, Nagoya University / Suresh Subramaniam, The George Washington University / Masahiko Jinno, Kagawa University / Hiroshi Hasegawa, Nagoya University

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Th4E.4

Add-Drop Lossless Switch Node in Multi-Hop Multi-Tb/s Metropolitan Area Networks

Presenter: Mariangela Rapisarda , *Politecnico di Milano*

The effect of SOA-based MAN node crossing on DMT high-capacity transmission is experimentally evaluated. A capacity of more than 50 Gb/s per channel is demonstrated for a multi-hop multi-channel transmission up to 116 km SSMF.

Authors:Mariangela Rapisarda, Politecnico di Milano / Alberto Gatto, Politecnico di Milano / Paola Parolari, Politecnico di Milano / Netsanet Tessema, Technische Universiteit Eindhoven / Nicola Calabretta, Technische Universiteit Eindhoven / Christian Neumeyr, Vertilas GmbH / Pierpaolo Boffi, Politecnico di Milano

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Th4E.5

Single-Photodiode 100 Gbaud PAM-6 Transmission With Extended Transmitter Bandwidth Using Optical Time and Polarization Interleaving

Presenter: Yan Fu , *Technical University of Denmark*

We demonstrate an optical time and polarization interleaving (OTPI) technique to extend the transmitter bandwidth. Using a single photodiode, 25-GHz DACs and modulators, 100 Gbaud OTPI-PAM-6 signals have been transmitted over 1 km NZDSF.

Authors:Yan Fu, Technical University of Denmark / xiaoling zhang, Technical University of Denmark / Deming Kong, Technical University of Denmark / Longsheng Li, Shanghai Jiao Tong University / shi jia, Technical University of Denmark / Weisheng Hu, Shanghai Jiao Tong University / Hao Hu, Technical University of Denmark

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Th4E.6

100 Gbit/s PAM-16 Transmission in the 2-μm Band Over a 1.15-km Hollow-Core Fiber

Presenter: Deming Kong , *Technical University of Denmark*

We demonstrate the first low-latency 2-μm-band PAM signal transmission using a hollow-core fiber (HCF). PAM-8 and PAM-16 signals are successfully transmitted over 1.15-km HCF with line rates of 96 Gbit/s and 100 Gbit/s, respectively.

Authors:Deming Kong, Technical University of Denmark / Zhengqi Ren, University of Southampton / Yong-min Jung, University of Southampton / Yong Chen, University of Southampton / Natalie Wheeler, University of Southampton / Michael Galili, Technical University of Denmark / Leif Oxenløwe, Technical University of Denmark / David Richardson, University of Southampton / Hao Hu, Technical University of Denmark

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Th4E.7

Scalable 1×N Switch via on-Chip Tunable Metasurface

Presenter: Yingjie Liu , *Harbin Institute of Technology (Shenzhen)*

An integrated 1×N switch is proposed and experimentally demonstrated via tunable silicon photonic metasurface which has an insertion loss of 3 dB and extinction ratio of 5 dB in the C band.

Authors:Yingjie Liu, Harbin Institute of Technology (Shenzhen) / Xi Wang, Harbin Institute of Technology (Shenzhen) / Yong Yao, Harbin Institute of Technology (Shenzhen) / Jiangbing Du, Shanghai Jiao Tong University / Qinghai Song, Harbin Institute of Technology (Shenzhen) / Ke Xu, Harbin Institute of Technology (Shenzhen)

Th4F

Fiber and Quantum Sensing Systems

Presider: Sang Yeup Kim

Th4F.1

Wireless Body-Area Networks in Medical Applications Using Optical Signal Transmission

Invited

Presenter: Mohammad Khalighi , *Ecole Centrale Marseille*

We consider optical wireless technology-based medical wireless body-area networks (WBANs). After presenting the most recent results on channel modeling and signal transmission, a new multiple access MAC layer scheme is proposed for intra-WBAN links.

Authors:Oussama Haddad, Ecole Centrale Marseille / Mohammad Khalighi, Ecole Centrale Marseille / Anatolij Zubow, TU Berlin

Th4F.2

Artificial Neural Networks for Distributed Optical Fiber Sensing

Invited

Presenter: Sascha Liehr , *DiGOS Potsdam GmbH*

This presentation reviews ANN-based approaches for improved and accelerated raw data processing, denoising, as well as higher-level tasks such as event recognition and classification.

Authors:Sascha Liehr, DiGOS Potsdam GmbH

Th4F.3

Field Demonstration of Distributed Quantum Sensing Without Post-Selection

Presenter: Si-Ran Zhao , *Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China*

We demonstrate distributed quantum sensing in field and show the unconditional violation (without post-selection) of shot-noise limit up to 0.916 dB with the averaged heralding efficiency of 73.88% for the field distance of 240 m.

Authors:Si-Ran Zhao, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Yu-Zhe Zhang, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Wen-Zhao Liu, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Jian-Yu Guan, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Weijun Zhang, State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai 200050, P. R. China / Cheng-Long Li, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Bing Bai, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Ming-Han Li, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Yang Liu, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Lixing You, State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai 200050, P. R. China / Jun Zhang, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Jingyun Fan, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Feihu Xu, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Qiang Zhang, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China / Jian-Wei Pan, Hefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China

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Th4F.4

Experimental Coexistence Investigation of Distributed Acoustic Sensing and Coherent Communication Systems

Presenter: Zhensheng Jia , *CableLabs*

We demonstrate the co- and counter-propagation coexistence of distributed acoustic sensing and 100G/200G coherent data communication over a single fiber, proving ubiquitous and practical sensing through pervasive telecom fiber infrastructure.

Authors:Zhensheng Jia, CableLabs / Miguel Gonzalez-Herraez, University of Alcala / Zhongwen Zhan, California Institute of Technology

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Th4G

Panel: PON Disaggregation, from SDN Abstraction to Full Virtualization. Benefits, Obstacles and Trends

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Th4H

Optical Field Trials

Presider: Qian Hu

Th4H.1

5G-Ready Railway Trial Utilizing Integrated Optical Passive WDM Access and Broadband Millimeter Wave

Invited

Presenter: Jim Zou , *ADVA Optical Networking SE*

We demonstrated Europe’s first 5G-ready railway trial in an operational environment by using a combined passive WDM and 60 GHz millimeter-wave transport solution. The trial achieved multi-Gbit/s seamless connectivity to a fast-moving train.

Authors:Jim Zou, ADVA Optical Networking SE

Th4H.2

Google Fiber Deployments: Lessons Learned and Future Directions

Invited

Presenter: Cedric Lam , *Google LLC*

In this paper, we recount the challenges encountered in 10 years of Google Fiber operation and the innovations we created to tackle these problems. We conclude with some suggestions for future broadband access network developments.

Authors:Cedric Lam, Google LLC

Th4H.3

Field Trial of Abnormal Activity Detection and Threat Level Assessment With Fiber Optic Sensing for Telecom Infrastructure Protection

Presenter: Tiejun Xia , *Verizon Communications Inc*

We report the field trial results of monitoring abnormal activities near deployed cable with fiber-optic-sensing technology for cable protection. Detection and position determination of abnormal events and evaluating the threat to the cable is realized.

Authors:Tiejun Xia, Verizon Communications Inc / Glenn Wellbrock, Verizon Communications Inc / Ming-Fang Huang, NEC Labs America, Inc / Shaobo Han, NEC Labs America, Inc / Yuheng Chen, NEC Labs America, Inc / Milad Salemi, NEC Labs America, Inc / Philip Ji, NEC Labs America, Inc / Ting Wang, NEC Labs America, Inc / Yoshiaki Aono, NEC Corporation

Th4H.4

Quantum Key Secured Communications Field Trial for Industry 4.0

Presenter: Robert Woodward , *Toshiba Research Europe Ltd.*

We seamlessly integrate quantum key distribution with >1Mb/s secure bit rate into a smart-manufacturing production network. This provides a 10Gb/s quantum key encrypted link with long-term stable operation, compatible with national network infrastructure.

Authors:Robert Woodward, Toshiba Research Europe Ltd. / James Dynes, Toshiba Research Europe Ltd. / Paul Wright, BT Labs / Catherine White, BT Labs / Ryan Parker, BT Labs / Adrian Wonfor, University of Cambridge / Zhiliang Yuan, Toshiba Research Europe Ltd. / Andrew Lord, BT Labs / Andrew Shields, Toshiba Research Europe Ltd.

Th4H.5

Black-Box Assessment of Optical Spectrum Services

Presenter: Kaida Kaeval , *ADVA*

A spectral sweep process is introduced to discover performance issues in optical spectrum services. We detect filtering penalty, spectral ripple/tilt and channel crosstalk in field measurements, potentially leading to increased service robustness in low-margin networks.

Authors:Kaida Kaeval, ADVA / Jörg-Peter Elbers, ADVA / Klaus Grobe, ADVA / Marko Tikas, Tele2 Estonia / Tobias Fehenberger, ADVA / Helmut Griesser, ADVA / Gert Jervan, Tallinn University of Technology

Th4I

Optical Interconnects and Networking

Presider: S. J. Ben Yoo

Th4I.1

Optical Networks for Memory-Driven Computing

Invited

Presenter: Terry Morris , *Hewlett Packard Enterprise*

Memory-driven computing, heterogeneous computing, and disaggregated system designs require photonic links having different characteristics than those found in hyperscale networks. Future architectures are discussed, requirements identified, an example system is examined, and conclusions presented.

Authors:Terry Morris, Hewlett Packard Enterprise

Th4I.2

A Non-Volatile Optical Memory in Silicon Photonics

Presenter: Jacqueline Geler Kremer , *IBM Research Europe*

We demonstrate a non-volatile optical memory element integrated in silicon photonics for low-power reconfigurable photonic circuits and neural networks. Stable transmission states are set by manipulating ferroelectric domains in $BaTiO_3$ films embedded in photonic waveguides.

Authors:Jacqueline Geler Kremer, IBM Research Europe / Felix Eltes, IBM Research Europe / Pascal Stark, IBM Research Europe / Ankita Sharma, IBM Research Europe / Daniele Caimi, IBM Research Europe / Bert Offrein, IBM Research Europe / Jean Fompeyrine, IBM Research Europe / Stefan Abel, IBM Research Europe

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Th4I.3

Experimental Demonstration of XOR Separation by on-Chip Training a Linear Silicon Photonic Circuit

Presenter: Guangwei Cong , *AIST (Natl Inst of Adv Indust Sci&Tech)*

We experimentally demonstrate XOR separation, a classical linearly inseparable problem, by on-chip training linear silicon photonic circuits that we proposed in OFC2020. This device implements nonlinear-projection-linear-separation principle and can perform classification tasks in machine learning.

Authors:Guangwei Cong, AIST (Natl Inst of Adv Indust Sci&Tech) / Noritsugu Yamamoto, AIST (Natl Inst of Adv Indust Sci&Tech) / Takashi Inoue, AIST (Natl Inst of Adv Indust Sci&Tech) / Yuriko Maegami, AIST (Natl Inst of Adv Indust Sci&Tech) / Morifumi Ohno, AIST (Natl Inst of Adv Indust Sci&Tech) / Shota Kita, NTT Basic Research labs / Shu Namiki, AIST (Natl Inst of Adv Indust Sci&Tech) / Koji Yamada, AIST (Natl Inst of Adv Indust Sci&Tech)

Th4I.4

Optical Interconnects for Large Scale Computing: How Do We Get Beyond the Cost & Power Wall?

Invited

Presenter: Marc Taubenblatt , *IBM TJ Watson Research Center*

Bandwidth demands for datacenter networks continues as performance increases and AI and new HPC workloads explode. Managing power and costs will require a range of solutions from new network architectures to co-packaging.

Authors:Marc Taubenblatt, IBM TJ Watson Research Center

Th4J

Machine Learning for Failure Management and Performance Estimation / Prediction

Presider: Konstantinos (Kostas) Christodoulopoulos

Th4J.1

Machine Learning for Failure Management in Optical Networks

Tutorial

Presenter: Francesco Musumeci , *Politecnico di Milano*

After an overview on main concepts of machine learning, we discuss use cases in optical networks failure management, such as failure detection, root-cause identification and localization. Recent research trends and challenges are also highlighted.

Authors:Francesco Musumeci, Politecnico di Milano

Th4J.2

GAN Based Soft Failure Detection and Identification for Long-Haul Coherent Transmission Systems

Presenter: Huazhi Lun , *Shanghai Jiao Tong University*

We propose a GAN based soft failure detection and identification algorithm. For the training, the detection and identification only need normal samples and very few soft failure samples, respectively. Over 95% accuracy is achieved in experiment.

Authors:Huazhi Lun, Shanghai Jiao Tong University / xiaomin liu, Shanghai Jiao Tong University / Meng Cai, Shanghai Jiao Tong University / Yiwen Wu, Shanghai Jiao Tong University / Mengfan Fu, Shanghai Jiao Tong University / Lilin Yi, Shanghai Jiao Tong University / Weisheng Hu, Shanghai Jiao Tong University / Qunbi Zhuge, Shanghai Jiao Tong University

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Th4J.3

Deep Convolutional Neural Network for Network-Wide QoT Estimation

Presenter: Pooyan Safari , *Fraunhofer Inst Nachricht Henrich-Hertz*

We propose a novel Deep Convolutional Neural Network formulation for network-wide QoT classification tasks and show its effectiveness for networks with significant topological differences. Our formulation achieves ~99% accuracy on large and diverse test datasets.

Authors:Pooyan Safari, Fraunhofer Inst Nachricht Henrich-Hertz / Behnam Shariati, Fraunhofer Inst Nachricht Henrich-Hertz / Geronimo Bergk, Fraunhofer Inst Nachricht Henrich-Hertz / Johannes Fischer, Fraunhofer Inst Nachricht Henrich-Hertz

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Th4J.4

Leveraging ML-Based QoT Tool Parameter Feeding for Accurate WDM Network Performance Prediction

Presenter: Nathalie Morette , *Huawei*

A novel technique to refine optical fiber network parameters for accurate performance estimation is presented. The technique exploits Raman and Kerr effects to improve new services' SNR estimation accuracy by 2dB based on experimental data.

Authors:Nathalie Morette, Huawei / Ivan Fernandez de Jauregui Ruiz, Huawei / Yvan Pointurier, Huawei

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Th4J.5

Forecasting Lightpath QoT With Deep Neural Networks

Presenter: Christine Tremblay , *École de technologie supérieure*

We propose multilayer perceptron (MLP) and long short-term memory (LSTM) deep neural network models trained with field data for forecasting the minimum quality of transmission of deployed lightpaths over horizons up to 72 hours.

Authors:Hussein Chouman, École de technologie supérieure / Petar Djukic, Ciena / Christine Tremblay, École de technologie supérieure / Christian Desrosiers, École de technologie supérieure

13:30 - 14:30 Pacific Time (US & Canada) (UTC - 07:00)

SF14

Exhibit Hall Event - Industry Program: 3D Sensing Uses in Consumer and Automotive Markets

14:00 - 15:30 Pacific Time (US & Canada) (UTC - 07:00)

SF15

Exhibit Hall Event - Industry Program: Embedded Optics for High Speed Switching

14:30 - 16:00 Pacific Time (US & Canada) (UTC - 07:00)

MW7

Exhibit Hall Event - Market Watch: Optical Interconnect and Computing for Scaling Machine Learning Systems

15:00 - 16:30 Pacific Time (US & Canada) (UTC - 07:00)

Th5H

Silicon Photonics for Data Center Networks

Presider: Rui Wang

Th5H.1

Accelerating Parallel Sort on Tightly-Coupled FPGAs Enabled by Onboard Si-Photonics Transceivers

Presenter: Kenji Mizutani , *PETRA*

We illustrate a case for a tightly-coupled lightweight fully-connected inter-FPGA optical network with Si-photonics transceivers. Counting sort of in-memory column-oriented data using eight custom FPGA cards can be 5.3 times faster than that with eight CPU-servers.

Authors:Kenji Mizutani, PETRA / Hiroshi Yamaguchi, PETRA / Yutaka Urino, PETRA / Michihiro Koibuchi, the National Institute of Informatics

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Th5H.2

Energy-Efficient and Scalable Data Centers With Flexible Bandwidth SiPh All-to-all Fabrics

Invited

Presenter: Roberto Proietti , *University of California Davis*

This paper presents a scalable and energy-efficient flexible-bandwidth optical interconnect architecture for data center networks. The proposed approach leverages silicon photonic reconfigurable all-to-all switch fabrics and a cognitive distributed control plane for optical reconfiguration.

Authors:Roberto Proietti, University of California Davis / Zhiyan Liu, University of California Davis / Xian Xiao, University of California Davis / Xiaoliang Chen, University of California Davis / S. J. Ben Yoo, University of California Davis

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Th5H.3

Silicon Photonic Switch-Enabled Server Regrouping Using Bandwidth Steering for Distributed Deep Learning Training

Presenter: Ziyi Zhu , *Columbia University*

We demonstrate SiP switch-enabled server regrouping using bandwidth steering for performance improvement in distributed deep learning training in a Fat-tree testbed. Our proposed SiP switch control scheme enables scaling to large-scale datacenter and HPC systems.

Authors:Ziyi Zhu, Columbia University / Shijia Yan, Columbia University / Madeleine Glick, Columbia University / Min Teh, Columbia University / Keren Bergman, Columbia University

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Tu1H.3

Time Stretch Computing for Ultrafast Single-Shot Data Acquisition and Inference

Invited

Presenter: Bahram Jalali , *University of California Los Angeles*

We introduce the concept of Lambda Kernel Computing – a method that accelerates inference by a nonlinear transformation of spectrally modulated data. Applications to time stretch microscopy and nonlinear classification are demonstrated.

Authors:Bahram Jalali, University of California Los Angeles / Tingyi Zhou, University of California Los Angeles / Fabien Scalzo, University of California Los Angeles

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15:00 - 17:00 Pacific Time (US & Canada) (UTC - 07:00)

Th5A

Silicon Photonics and Resonant Modulators

Presider: Erman Timurdogan

Th5A.1

High Temperature Performance of Heterogeneous MOSCAP Microring Modulators

Presenter: sudharsanan srinivasan , *Hewlett Packard Enterprise*

We present results from our heterogeneous MOSCAP microring modulators, which show no degradation in performance from 20 to 80 °C, and are suitable for integration on uncooled transceivers operating in a harsh environment.

Authors:sudharsanan srinivasan, Hewlett Packard Enterprise / Di Liang, Hewlett Packard Enterprise / Raymond Beausoleil, Hewlett Packard Enterprise

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Th5A.2

Neuromorphic Photonic Networks

Invited

Presenter: Bhavin Shastri , *Queen's University*

Neuromorphic photonics exploit optical device physics for neuron models, and optical interconnects for distributed, parallel, and analog processing for high-bandwidth, low-latency and low switching energy applications in artificial intelligence and neuromorphic computing

Authors:Bhavin Shastri, Queen's University / Simon Bilodeau, Princeton University / Bicky Marquez, Queen's University / Alexander Tait, Princeton University / Thomas Ferreira de Lima, Princeton University / Chaoran Huang, Princeton University / Lukas Chrostowski, University of British Columbia / Sudip Shekhar, University of British Columbia / Paul Prucnal, Princeton University

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Th5A.3

MOSCAP Ring Modulator With 1.5 μm Radius, 8.5 THz FSR and 30 GHz/v Shift Efficiency in a 45 nm SOI CMOS Process

Presenter: Hayk Gevorgyan , *Boston University*

We demonstrate the smallest microring modulator to date, with 1.5 μm radius, record 8.5 THz FSR and 30 GHz/V O-band shift efficiency, using a MOSCAP structure in a new 45 nm monolithic CMOS electronic-photonic process (45CLO). It could enable massively-parallel optical links with low energy and high bandwidth density.

Authors:Hayk Gevorgyan, Boston University / Anatol Khilo, Ayar Labs Inc. / Mark Wade, Ayar Labs Inc. / Vladimir Stojanovic, University of California, Berkeley / Milos Popovic, Boston University

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Th5A.4

Analog ASIC for Silicon Photonics

Tutorial

Presenter: Alexander Rylyakov , *Nokia*

We will review and compare key metrics and challenges of driver, TIA design and overall “photonic engine” transceiver architectures for optical links based on silicon photonics for coherent and direct-detection (PAM-4) high-speed communication applications.

Authors:Alexander Rylyakov, Nokia

Th5B

Multi-mode Fibers

Presider: Roland Ryf

Th5B.1

Learning to See and Compute Through Multimode Fibers

Invited

Presenter: Christophe Moser , *Ecole Polytechnique Federale de Lausanne*

We propose a method for controlling the output of a multimode fiber using machine learning. Arbitrary images can be projected with amplitude-only calibration. We also show that MMF can be used to perform learning tasks.

Authors:Babak Rahmani, Ecole Polytechnique Federale de Lausanne / Ugur Tegin, Ecole Polytechnique Federale de Lausanne / Mustafa Yildirim, Ecole Polytechnique Federale de Lausanne / Ilker Oguz, Ecole Polytechnique Federale de Lausanne / Damien Loterie, Readily3D / Eirini Kakkava, Ecole Polytechnique Federale de Lausanne / Navid Bohrani, Ecole Polytechnique Federale de Lausanne / Demetri Psaltis, Ecole Polytechnique Federale de Lausanne / Christophe Moser, Ecole Polytechnique Federale de Lausanne

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Th5B.2

Performance of Single-Mode Transmission Over Multimode Fiber: Offset Launch v.s. Fundamental Mode Launch

Presenter: Bulent Kose , *Panduit Corp.*

We study single mode transmission over multimode fiber, and investigate performance difference when the launch is offset patch cord versus center launch. BER performance and optical eye diagram plots with 10GBASE LRM 10GBASE-LR transceivers are presented.

Authors:Bulent Kose, Panduit Corp. / Jose Castro, Panduit Corp. / Rick Pimpinella, Panduit Corp. / Paul Huang, Panduit Corp. / Brett Lane, Panduit Corp.

Th5B.3

Measurement of Propagation Constants of Graded Index Multi-Mode Fiber Using Rayleigh Backscattered Light

Presenter: Lauren Dallachiesa , *Nokia Bell Labs*

We measure the distributed differential group delay and effective refractive index difference between all 9 mode groups of a graded index multi-mode fiber using optical frequency domain reflectometry by cross correlating Raleigh backscatter signals.

Authors:Lauren Dallachiesa, Nokia Bell Labs / Riccardo Veronese, University of Padova / Nicolas Fontaine, Nokia Bell Labs / Mikael Mazur, Nokia Bell Labs / Haoshuo Chen, Nokia Bell Labs / Roland Ryf, Nokia Bell Labs / Luca Palmieri, University of Padova / Marianne Bigot, Prysmian Group / Pierre Sillard, Prysmian Group

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Th5B.4

Spectral and Spatial Shaping of Light in Multimode Fibers

Tutorial

Presenter: Joel Carpenter , *University of Queensland*

The concepts and techniques of spatial mode conversion and spectral pulse shaping will be explored. Looking at how spatial and spatiotemporal modes can be precisely excited or detected in a multimode fiber.

Authors:Joel Carpenter, University of Queensland

Th5C

Panel: Advanced Laser Technologies in Post-100Gbaud Era

Th5D

Transceiver Calibration and Modelling

Presider: Zhensheng Jia

Th5D.1

Simultaneously Precise Calibration of Frequency Response and IQ Skew for 100Gbaud Optical Transceiver

Presenter: Li Di , *Huazhong University of Sci. & Tech.*

We report a precise calibration method that can simultaneously characterize both frequency response and IQ-skew of coherent optical transceivers. 100GBaud-Nyquist-16QAM and 80GBaud-Nyquist-64QAM signal can be obtained by the use of commercial class-40 CDM and ICR.

Authors:Li Di, Huazhong University of Sci. & Tech. / zexin chen, Huazhong University of Sci. & Tech. / li zhang, Huawei Technologies Co., Ltd / pin yi, Huazhong University of Sci. & Tech. / haiping song, Huazhong University of Sci. & Tech. / megnfan cheng, Huazhong University of Sci. & Tech. / Songnian Fu, Guangdong University of Technology / Ming Tang, Huazhong University of Sci. & Tech. / Yuwen Qin, Guangdong University of Technology / deming liu, Huazhong University of Sci. & Tech. / lei deng, Huazhong University of Sci. & Tech. / jingchuan wang, Huazhong University of Sci. & Tech.

Th5D.2

Simultaneous Monitoring of Frequency-Dependent IQ Imbalances in a Dual-Polarization IQ Modulator by Using a Single Photodetector: a Phase Retrieval Approach

Presenter: Yuki Yoshida , *National Inst of Information & Comm Tech*

A low-complexity frequency-dependent IQ imbalance monitoring technique for a dual-polarization (DP) IQ modulator by using a single photodetector is proposed based on phase retrieval and demonstrated experimentally with a 63.25-Gbaud DP-16QAM signal.

Authors:Yuki Yoshida, National Inst of Information & Comm Tech / Setsuo Yoshida, Fujitsu Limited / Shoichiro Oda, Fujitsu Limited / Takeshi Hoshida, Fujitsu Limited / Naokatsu Yamamoto, National Inst of Information & Comm Tech

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Th5D.3

Direct-Detection Based Frequency-Resolved I/Q Imbalance Calibration for Coherent Optical Transmitters

Presenter: Xi Chen , *Nokia Bell Labs*

We propose a method for calibrating the frequency dependent I/Q imbalance in coherent optical transmitters. We demonstrate that with our calibration, the OSNR penalty of a 58-GBaud 256-QAM signal can be reduced by 2.5 dB.

Authors:Xi Chen, Nokia Bell Labs / Di Che, Nokia Bell Labs

Th5D.4

In-Field Calibration of Phase Response of Optical Transmitter Using Built-in Monitor Photodiode

Presenter: Yangyang Fan , *FRDC*

The in-field calibration of the phase response of high-capacity optical transmitters is proposed with the assistance of the narrow-band photodiode built in Mach-Zehnder modulator. The ±1° measurement error within signal bandwidth is experimentally demonstrated.

Authors:Yangyang Fan, FRDC / Zhenning Tao, FRDC / Hisao Nakashima, Fujitsu Ltd. / Takeshi Hoshida, Fujitsu Ltd.

Th5D.5

Performance Prediction of 100 Gb/s PAM4 Optical Systems Using a Frequency Dependent Nonlinear Model

Presenter: Christian Malouin , *Intel*

A frequency-dependent nonlinear model has been proposed and experimentally verified at 100 Gb/s using PAM4. This universal model simply requires adjusting two sets of polynomials based on the THD data and is modulation format agnostic

Authors:Christian Malouin, Intel / Siamak Amiralizadeh, Intel / Yann Malinge, Intel / Raghuram Narayan, Intel / Kadhair Al-hemyari, Intel / Sanjeev Gupta, Intel / Syed S. Islam, Intel / Yiching Lin, Intel / Wenhua Lin, Intel / Jin Hong, Intel

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Th5D.6

Generalized Soft Failure Identification Enabled by Digital Residual Spectrum and Autoencoder

Presenter: Kaixuan Sun , *Beijing University of Posts and Telecomm*

We propose a highly generalized soft failure identification model based on digital residual spectrum and autoencoder. In case of random fluctuation, it could reach identification accuracy of more than 97.61% for five different transmission distances.

Authors:Kaixuan Sun, Beijing University of Posts and Telecomm / Yu Zhenming, Beijing University of Posts and Telecomm / Liang Shu, Beijing University of Posts and Telecomm / Zhiquan Wan, Beijing University of Posts and Telecomm / Kun Xu, Beijing University of Posts and Telecomm

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Th5E

Optical-wireless Converged Transmission Systems

Presider: Christina Lim

Th5E.1

Underwater and Water-air Optical Wireless Communication

Invited

Presenter: Lian-Kuan Chen , *Chinese University of Hong Kong*

This paper summarizes the recent trend and progress of underwater and water-air optical wireless communications. Channel characterization, communication system performance, and effective mitigation methods under the influence of bubble and wave are discussed.

Authors:Lian-Kuan Chen, Chinese University of Hong Kong / Yingjie Shao, Chinese University of Hong Kong / Yujie Di, Chinese University of Hong Kong

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Th5E.2

Adaptive Loading for Water-air SIMO OWC System Based on the Temporal and Spatial Properties of Waves

Presenter: Yingjie Shao , *Chinese University of Hong Kong*

We demonstrated a proactive adaptive loading scheme for air-water SIMO OWC system through waves based on the prediction of wave characteristics. A maximum of 96.2% increase in throughput is realized by temporal and spatial diversities.

Authors:Yingjie Shao, Chinese University of Hong Kong / Yujie Di, Chinese University of Hong Kong / Lian-Kuan Chen, Chinese University of Hong Kong

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Th5E.3

Single-Wavelength Terabit FSO Channel for Datacenter Interconnects Enabled by Adaptive PCS

Presenter: Marco Fernandes , *Instituto de Telecomunicações de Aveiro*

Using coherent optics we demonstrate a seamless fiber-FSO link for DCIs supporting up to 1 Tbps. PCS-based bit-rate adaptation and automatic beam alignment effectively counteract the impact of pointing errors. To the best of our knowledge, this is the highest reported FSO bitrate using single-wavelength transmission.

Authors:Marco Fernandes, Instituto de Telecomunicações de Aveiro / Paulo Monteiro, Instituto de Telecomunicações de Aveiro / Fernando Guiomar, Instituto de Telecomunicações de Aveiro

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Th5E.4

115-Gbps/λ Fiber/FSO Transmission With Supervised and Semi-Supervised Nonlinearity Correction Using Lasso

Presenter: Rui Zhang , *Georgia Institute of Technology*

We leverage supervised/semi-supervised methods and Lasso to perform nonlinearity compensations in a fiber/FSO system. A proof-of-concept experiment has demonstrated up to 3.1-dB power-margin improvement and significantly reduced pilot symbol ratio.

Authors:Rui Zhang, Georgia Institute of Technology / Xizi Tang, Georgia Institute of Technology / Chin-Wei Hsu, Georgia Institute of Technology / You-Wei Chen, Georgia Institute of Technology / Qi Zhou, Georgia Institute of Technology / Shuyi Shen, Georgia Institute of Technology / Shuang Yao, Georgia Institute of Technology / Yahya Alfadhli, Georgia Institute of Technology / Shang-Jen Su, Georgia Institute of Technology / Gee-Kung Chang, Georgia Institute of Technology

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Th5E.5

LDPC Coded PAM-4/8 Transmission in Fiber-FSO Link Using Unipolar Probability Distribution and Pre-Distortion

Presenter: Rui Zhang , *Georgia Institute of Technology*

We experimentally demonstrated LDPC coded PAM transmission with unipolar distribution and pre-distortion in a fiber-FSO hybrid link with the parity bits inserted in the LSB. Different schemes are experimentally compared with up to 2.1-dB sensitivity improvement.

Authors:Rui Zhang, Georgia Institute of Technology / Chin-Wei Hsu, Georgia Institute of Technology / Xizi Tang, Georgia Institute of Technology / Qi Zhou, Georgia Institute of Technology / Gee-Kung Chang, Georgia Institute of Technology

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Th5E.6

Demonstration of Spatial Multiplexing by Digital Beamforming in 5G Fiber-Wireless Integrated Network

Presenter: Shang-Jen Su , *Georgia Institute of Technology*

Multiple data streams sharing the same time-frequency resource block through digital beamforming technique are received at different angles of arrival by a 1-by-4 antenna array and decoded simultaneously in 5G fiber-wireless integrated access network.

Authors:Shang-Jen Su, Georgia Institute of Technology / Chin-Wei Hsu, Georgia Institute of Technology / Shuyi Shen, Georgia Institute of Technology / Shuang Yao, Georgia Institute of Technology / Yahya Alfadhli, Georgia Institute of Technology / Rui Zhang, Georgia Institute of Technology / Qi Zhou, Georgia Institute of Technology / Gee-Kung Chang, Georgia Institute of Technology

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Th5F

Coherent/Free-space Optics for Data-center Applications

Presider: Madeleine Glick

Th5F.1

Phase Retrieval-Based Coherent Receivers

Invited

Presenter: Joseph Kahn , *Stanford University*

We compare the fundamental performance of Kramers-Kronig detection to that of standard local oscillator-based coherent detection and standard direct detection in optically amplified links, highlighting the effects of the carrier-to-signal power ratio, chromatic dispersion, and probabilistic shaping.

Authors:Elaine Chou, Stanford University / Hrishikesh Srinivas, Stanford University / Joseph Kahn, Stanford University

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Th5F.2

Silicon Photonics Coherent Optical Subassembly for High-Data-Rate Signal Transmission

Invited

Presenter: Shogo Yamanaka , *NTT Corporation*

We present silicon photonics coherent optical subassemblies for digital coherent optical systems. We also demonstrate up to 96-Gbaud 16QAM transmission experiments.

Authors:Shogo Yamanaka, NTT Corporation / Yusuke Nasu, NTT Corporation

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Th5F.3

Virtual Carrier Assisted Self-Coherent Detection Employing DC-Value Method

Presenter: Romil Patel , *Instituto de Telecomunicações*

We experimentally demonstrate for the first time the performance of the DC-Value (DC-V) phase recovery method in direct-detection optical links. It offers greater than 13% BER improvement in QPSK transmission compared to state-of-art upsampling-free methods.

Authors:Romil Patel, Instituto de Telecomunicações / Fernando Guiomar, Instituto de Telecomunicações / Marco Fernandes, Instituto de Telecomunicações / Isiaka Alimi, Instituto de Telecomunicações / Paulo Monteiro, Instituto de Telecomunicações / Nelson Muga, Instituto de Telecomunicações / Armando Pinto, Instituto de Telecomunicações

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Th5F.4

Demonstration of Single-Lane 350-Gb/s PS-PAM-16 in the C-Band Using Single-DAC for Data Center Interconnects

Presenter: Jiao Zhang , *Southeast University*

We experimentally demonstrated single-lane 100-Gbaud PAM-8 and PS-PAM-16 signals IM/DD transmission over 1-km NZDSF using one single-DAC and single-Photodiode with joint nonlinear equalization techniques. 350-Gb/s PS-PAM-16 signal transmission can be achieved.

Authors:Jiao Zhang, Southeast University / Min Zhu, Southeast University / Kaihui Wang, Fudan University / Bingchang Hua, Southeast University / Mingzheng Lei, Southeast University / Yuancheng Cai, Southeast University / Yucong Zou, Southeast University / Aijie Li, Southeast University / Jikuan Wang, Southeast University / Weiliang Xu, Southeast University / Xiang Liu, Southeast University / Qingyi Zhou, Southeast University / Jianjun Yu, Purple Mountain Laboratories

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Th5G

Panel: Pros and Cons of Low-margin Optical Networks

Th5I

Evolution of Coherent PON Technology

Presider: Liang Du

Th5I.1

Enabling Technologies for Comprehensive Optical Mobile Fronthaul Access Network

Invited

Presenter: Weisheng Hu , *Shanghai Jiaotong University*

In this paper, we review the recent progress of our works on a comprehensive optical mobile fronthaul access network for 5G Era and beyond. Enabling technologies including A-RoF, CPRI, eCPRI and hybrid A/D-RoF are introduced.

Authors:Weisheng Hu, Shanghai Jiaotong University / Yixiao Zhu, Shanghai Jiaotong University / Longsheng Li, Shanghai Jiaotong University / Kuo Zhang, Shanghai Jiaotong University / Haiyun Xin, Shanghai Jiaotong University / Yan Fu, Shanghai Jiaotong University / Xin Miao, Shanghai Jiaotong University

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Th5I.2

Low-Complexity Phase-and-Polarization-Diversity Coherent Receiver With High Spectral Efficiency for UDWDM

Presenter: Jeison Tabares , *POLYTECHNIC UNIVERSITY OF CATALONIA*

We propose a phase-and-polarization-diversity coherent heterodyne receiver with low-cost 3x3 coupler optical front-end. Using simple DSP, the image-frequency band is rejected, and the receiver sensitivity is improved by 3dB, compared with conventional heterodyne detection.

Authors:Jeison Tabares, POLYTECHNIC UNIVERSITY OF CATALONIA / Josep Prat, POLYTECHNIC UNIVERSITY OF CATALONIA

Th5I.3

Wavelength Collision-Free and Low-Loss Full-Duplex Transmission Over Switchable Full-Coupling or Half-Split Coherent WDM-PON System With Shared Protection

Presenter: Takahiro Kodama , *Kagawa University*

We propose low-loss and high-tolerance shared protection for full-duplex coherent wavelength division multiplexing-passive optical network systems, achieving < 2 dB penalty with small back reflection in wavelength collision-free secondary link transmissions with primary link failure.

Authors:Takahiro Kodama, Kagawa University / Tetsuji Goto, Kagawa University / Ryosuke Matsumoto, National Institute of Advanced Industrial Science and Technology (AIST)

Th5I.4

Adaptive Modulation and Coding Scheme in Coherent PON for Enhanced Capacity and Rural Coverage

Presenter: Mu Xu , *CableLabs*

An adaptive coded-modulation approach combining QAM and shortened LDPC is proposed in coherent-PON architecture. The BER performance was experimentally verified and network simulations using operator data indicated in-average 40.2% increased capacity and 47.6% improved coverage.

Authors:Mu Xu, CableLabs / Haipeng Zhang, CableLabs / Zhensheng Jia, CableLabs / Luis Campos, CableLabs

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Th5I.5

Simplified Digital Coherent Technologies for Beyond 100G Optical Access Systems in the B5G/6G era

Invited

Presenter: Naoki Suzuki , *Mitsubishi Electric Corporation*

We review the latest progress in simplified digital coherent technologies suitable for beyond 100G optical access systems, which will be a key optical platform for meeting the very wide range of extreme requirements of beyond 5G/6G users.

Authors:Naoki Suzuki, Mitsubishi Electric Corporation / Hiroshi Miura, Mitsubishi Electric Corporation / Keita Mochizuki, Mitsubishi Electric Corporation / Keisuke Matsuda, Mitsubishi Electric Corporation

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17:00 - 17:30 Pacific Time (US & Canada) (UTC - 07:00)

TSC23

Exhibit Hall Event - Technology Showcase: Synopsys Photonic IC Platform: Enabling Seamless Design of Optical Communications, Sensing, and Bio-Photonics Products

17:00 - 19:00 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

Special Event - Demo Zone Demonstrations in Action

17:30 - 18:00 Pacific Time (US & Canada) (UTC - 07:00)

TSC24

Exhibit Hall Event - Technology Showcase: The Evolution of Connectivity Automating the Fiber Layer

Friday, 11 June

3:00 - 5:00 Pacific Time (US & Canada) (UTC - 07:00)

F1A

Visible Light Communication

Presider: Nan Chi

F1A.1

3.129-Gbit/s OFDM Visible Light Communication Using Semipolar Green μ-Light Emitting Diode (μ-LED) Array

Presenter: Yun-Han chang , *National Chiao Tung University*

We propose and demonstrate 3.129 Gbit/s orthogonal-frequency-division-multiplexing (OFDM) visible-light-communication (VLC) system using 550 nm wavelength green semipolar (20-21) InGaN/GaN μ-LED-array. The produced μ-LED-array has a high 3-dB bandwidth of 1.06 GHz driven at 90 mA.

Authors:Yun-Han chang, National Chiao Tung University / Guan-Hao Chang, National Chiao Tung University / Fang-Jyun Liou, National Chiao Tung University / CHING-WEI PENG, National Chiao Tung University / W. H. Gunawan, National Chiao Tung University / Chi-Wai Chow, National Chiao Tung University / Hao-Chung Kuo, National Chiao Tung University / Yang Liu, Philips Electronics Ltd / Chien-Hung Yeh, Feng Chia University

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F1A.2

Doubling the Spectral Efficiency With EVM as the Objective Function for Training Neural Networks in Non-Orthogonal Visible Light Communications Systems

Presenter: Paul Haigh , *Newcastle University*

We experimentally demonstrate, for the first time, that neural network detector performance can be enhanced by using EVM as the objective loss function. This method allows bandwidth compression up to 50% in non-orthogonal VLC systems.

Authors:Paul Haigh, Newcastle University / Scott Stainton, Newcastle University

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F1A.3

Embedded Orthogonal-Frequency-Division-Multiplexing (OFDM) to Color-Shift-Keying (CSK) Modulation for Laser-Diode Based Visible Light Communication (VLC)

Presenter: W. H. Gunawan , *National Chiao Tung University*

We experimentally demonstrate an embedded orthogonal-frequency-division-multiplexing (OFDM) to color-shift-keying (CSK) modulation for laser-diode (LD) based visible-light-communication (VLC) achieving 26.65-Gbit/s with 1.25-m free-space transmission.

Authors:W. H. Gunawan, National Chiao Tung University / Chi-Wai Chow, National Chiao Tung University / Yang Liu, Philips Electronics Ltd / Chien-Hung Yeh, Feng Chia University

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F1A.4

Z-Score Averaging Neural Network and Background Content Removal for High Performance Rolling Shutter Based Optical Camera Communication (OCC)

Presenter: Yun-Shen Lin , *National Chiao Tung University*

We propose and demonstrate using Z-score averaging neural-network (Z-NN) and background-content-removal (BCR) to mitigate the inter-symbol-interference (ISI) in camera-communication (OCC). 950-bit/s over 3-m free-space transmission is achieved.

Authors:Yun-Shen Lin, National Chiao Tung University / Yang Liu, Philips Electronics Ltd / Chi-Wai Chow, National Chiao Tung University / Yun-Han chang, National Chiao Tung University / Dong-Chang Lin, National Chiao Tung University / Shao-Hua Song, National Chiao Tung University / Ke-Ling Hsu, National Chiao Tung University / Chien-Hung Yeh, Feng Chia University

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F1A.5

99.999% Transmission Reliability Based on MAC Layer Feedback-Repeat Scheme for LiFi Networking With B5G/6G

Presenter: Qiguan Chen , *State Key Lab of Info. Photon. & Opt. Co*

A degenerated MAC layer feedback-repeat reliable transmission scheme was proposed and experimentally demonstrated for LiFi networking with B5G/6G. The experimental results of end-to-end packet loss ratio precedes 1/10000 (equals to 99.999% reliability).

Authors:Qiguan Chen, State Key Lab of Info. Photon. & Opt. Co / Min Zhang, State Key Lab of Info. Photon. & Opt. Co / Dahai Han, State Key Lab of Info. Photon. & Opt. Co / Zhiguo Zhang, State Key Lab of Info. Photon. & Opt. Co / Weishu Xu, State Key Lab of Info. Photon. & Opt. Co

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F1A.6

VLC Using a Red SMD LED as 2.48 Gb/s Multi-Carrier Receiver and Wide Field-of-View 25 Mb/s OOK Transmitter

Presenter: Dinka Milovancev , *AIT Austrian Institute of Technology*

A single-color LED is used as transceiver, achieving 2.48 Gb/s downlink reception with laser pencil beam over 2 m, and 25 Mbaud uplink transmission using APD- and SPAD-based receivers over 1 and 2 m, respectively.

Authors:Dinka Milovancev, AIT Austrian Institute of Technology / Nemanja Vokic, AIT Austrian Institute of Technology / Bernhard Schrenk, AIT Austrian Institute of Technology

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F1A.7

Benefits of MIMO Mode Switching, Angular Diversity and Multiuser Multiplexing for LiFi

Presenter: sepideh Mohammadi Kouhini , *Fraunhofer Heinrich Hertz Institute*

We report on the first real-time experiments with distributed MIMO and multiple users for LiFi. MIMO mode switching and angular diversity are beneficial for robustness. Multiuser multiplexing helps in scenarios where users have complementary MIMO channels.

Authors:sepideh Mohammadi Kouhini, Fraunhofer Heinrich Hertz Institute / Peter Hellwig, Fraunhofer Heinrich Hertz Institute / Dominic Schulz, Fraunhofer Heinrich Hertz Institute / Ronald Freund, Fraunhofer Heinrich Hertz Institute / Volker Jungnickel, Fraunhofer Heinrich Hertz Institute

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F1A.8

Optimizations of Probabilistic Constellation Shaping Superposition Schemes for the MISO Visible Light Communication System

Presenter: PENG ZOU , *Fudan University*

Two probabilistic-constellation-shaping (PCS) superposition schemes are proposed in the multi-input-single-output (MISO) visible-light-communication (VLC) system. Performance optimizations of 2.3Gbps MISO-VLC using global and local PCS superposition schemes are experimentally demonstrated in linear and nonlinear operation ranges.

Authors:PENG ZOU, Fudan University / Junwen Zhang, Fudan University / Guoqiang Li, Fudan University / Fangchen Hu, Fudan University / Nan Chi, Fudan University

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F1B

Nonlinear and Optomechanical Subsystems

Presider: David Marpaung

F1B.1

Whole Band Wavelength Conversion for Wideband Transmission

Invited

Presenter: Tomoyuki Kato , *Fujitsu Ltd.*

We introduce wavelength conversion technology for wideband transmission over deployed optical fibers by extending the wavelength range within the optical fiber transparent window which is not yet supported by practical transceivers.

Authors:Tomoyuki Kato, Fujitsu Ltd. / Shigeki Watanabe, Fujitsu Ltd. / Tomohiro Yamauchi, Fujitsu Ltd. / Goji Nakagawa, Fujitsu Ltd. / Hidenobu Muranaka, Fujitsu Ltd. / Yu Tanaka, Fujitsu Ltd. / Yuichi Akiyama, Fujitsu Ltd. / Takeshi Hoshida, Fujitsu Ltd.

F1B.2

Effective Linewidth Reduction in Self-Homodyne Coherent Reception Enabled by Stimulated Brillouin Scattering

Presenter: Cai Li , *Monash University*

We significantly narrow the effective linewidth in a coherent optical link from 75 kHz to ~ 2 kHz using SBS-based optical carrier recovery. Experiment results show that the phase recovery window length can be enlarged by over 100x with less than 0.5 dB Q^2 penalty.

Authors:Cai Li, Monash University / Moritz Merklein, The University of Sydney / Yang Liu, The University of Sydney / Amol Choudhary, Indian Institute of Technology (IIT) / Benjamin Eggleton, The University of Sydney / Bill Corcoran, Monash University

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F1B.3

Carrier Enhancement for Multichannel Kramers–Kronig Detection via Self-Seeded Brillouin Amplification

Presenter: Honghui Zhang , *The Chinese University of Hong Kong*

We experimentally demonstrate performance improvement of 5×10-Gbaud 16-QAM single-sideband signals using a carrier recovery block enabled by self-seeded Brillouin amplification after 80-km fiber transmission. The optimum average Q factor improvement is 3.0 dB.

Authors:Honghui Zhang, The Chinese University of Hong Kong / Qiulin Zhang, The Chinese University of Hong Kong / Chester C.T. Shu, The Chinese University of Hong Kong

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F1B.4

Reduced Impact of Frequency Dithering on the Performance of High-Order Modulation Format Phase Conjugation

Presenter: Abdallah Ali , *Aston Institute of Photonic Technologies*

We address the primary degradations in optical phase conjugation devices, reducing the implementation penalty to below 0.2dB and enabling, for the first time, performance improvement in a 400-km long probabilistically shaped 256-QAM transmission system.

Authors:Abdallah Ali, Aston Institute of Photonic Technologies / Tu Nguyen, Aston Institute of Photonic Technologies / Sonia Boscolo, Aston Institute of Photonic Technologies / Shigehiro Takasaka, Furukawa Electric Co. Ltd / Ryuichi Sugizaki, Furukawa Electric Co. Ltd / Andrew Ellis, Aston Institute of Photonic Technologies

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F1B.5

Capturing Nonlinear Signal Distortions by the Spectral Correlation Method

Presenter: Lutz Rapp , *ADVA*

Experimental results show that the spectral correlation method is suitable for characterizing the impact of nonlinear fiber effects on signal quality in agile, disaggregated and open optical networks.

Authors:Lutz Rapp, ADVA / Florian Azendorf, ADVA / Wolfgang Moench, Viavi Solutions Deutschland GmbH

F1B.6

Opto-Mechanical Inter-Core Cross-Talk in Multi-Core Fibers

Invited

Presenter: Avi Zadok , *Bar-Ilan University*

The constituent cores of multi-core fibers are coupled by acoustic modes, guided by the entire cladding cross-section. Acoustic coupling leads to inter core cross phase modulation. The effect is quantified in analysis and experiment.

Authors:Hilel Diamandi, Bar-Ilan University / Avi Zadok, Bar-Ilan University

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F1C

Open Disaggregated Optical Networks

Presider: Ricardo Martínez

F1C.1

Mathematical Model of Optical Functional Blocks for Automating Fully Disaggregated Optical Networks

Invited

Presenter: Kiyo Ishii , *AIST Tokyo*

Full visibility into an optical network at the component level is indispensable for the precise and rapid optimization of network configurations. A functional block–based disaggregation (FBD) model is introduced to realize a component-level automatic resource management mechanism.

Authors:Kiyo Ishii, AIST Tokyo / Shu Namiki, AIST Tokyo

F1C.2

Blade Abstraction Interface for Diverse Blade Integration and Unified Control of Disaggregate/Legacy ROADMs

Presenter: Sugang Xu , *National Institute of Information and Communications Technology (NICT)*

We propose a blade abstraction interface (BAI) for unifying the blade control and easing the use of diverse blades in heterogeneous ROADMs, also demonstrate the integration of disaggregate, legacy ROADMs and a hybrid node in disaster recovery.

Authors:Sugang Xu, National Institute of Information and Communications Technology (NICT) / Kiyo Ishii, National Institute of Advanced Industrial Science and Technology (AIST) / Noboru Yoshikane, KDDI Research, Inc. / Takehiro Tsuritani, KDDI Research, Inc. / Yoshinari Awaji, National Institute of Information and Communications Technology (NICT) / Shu Namiki, National Institute of Advanced Industrial Science and Technology (AIST)

F1C.3

Testing TIP Open Source Solutions in Deployed Optical Networks

Presenter: Emanuele Virgillito , *Politecnico di Torino*

Standardization in optical networking enables operators to benefit from using open source components. We investigate quality of transmission of open source hard- and software in the Deutsche Telekom R&D SASER network and optimize the working point.

Authors:Emanuele Virgillito, Politecnico di Torino / Ralf-Peter Braun, Deutsche Telekom / Dirk Breuer, Deutsche Telekom / Andreas Gladisch, Deutsche Telekom / Vittorio Curri, Politecnico di Torino / Gert Grammel, Juniper

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F1C.4

How Intent-Based Networking Can be Embedded Within Transport Optical Networks

Tutorial

Presenter: Luis Velasco , *Universitat Politecnica de Catalunya*

This tutorial covers intent-based networking, automated optical transmission and networking, and control-loops, and it shows how optical transport networks can be automated and be prepared for beyond 5G smart network services and applications.

Authors:Luis Velasco, Universitat Politecnica de Catalunya

F1D

Optical Access Technology in Support of Mobile Site Connectivity

Presider: Paola Parolari

F1D.1

4G to 6G: Disruption and Drivers for Optical Transport Network

Tutorial

Presenter: Chathurika Ranaweera , *Deakin University*

Optical transport (x-haul) plays a significant role in supporting next-generation wireless networks to achieve their key performance indicators. This tutorial provides insight into how the optical x-haul has been evolved to aid 5G and beyond networks.

Authors:Chathurika Ranaweera, Deakin University / Elaine Wong, The University of Melbourne / Christina Lim, The University of Melbourne / Ampalavanapillai Nirmalathas, The University of Melbourne

F1D.2

Digital Orthogonal Filtering-Enabled Synchronous Transmissions of I/Q Waveforms and Control Words for Bandwidth-Efficient and Low-Complexity Mobile Fronthaul

Presenter: Mingliang Deng , *CQUPT*

We experimentally demonstrate digital orthogonal filtering-enabled synchronous transmissions of 24 20MHz LTE signals and CWs, achieving an EVM of 3.1% and a SNR of 31.4dB for I/Q waveforms and CWs, respectively, over a 6km SSMF.

Authors:Mingliang Deng, CQUPT / Timera Mamadou, CQUPT / Zhibo Xing, CQUPT / Xuan Kang, CQUPT / Zhirui Luo, CQUPT / Jingwei Shi, CQUPT / Le Wang, CQUPT

F1D.3

Novel Scalable and Reconfigurable Converged Optical Fronthaul Network for Radio Frequency and Data Services Using Silicon Photonic Switching

Presenter: Junfei Xia , *University of Cambridge*

We propose and demonstrate a converged optical fronthaul network for RF and data services with scalable silicon photonic switching. A 1.5dB power penalty at a 10^{-9} BER and over 40dB RF dynamic range are demonstrated.

Authors:Junfei Xia, University of Cambridge / Tongyun Li, University of Cambridge / Qixiang Cheng, University of Cambridge / Shuai Yang, University of Cambridge / Keren Bergman, Columbia University / Richard Penty, University of Cambridge

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F1D.4

Demonstration of AI-Assisted Intent-Based Traffic Grooming in 5G Optical Access Network

Presenter: Luyao Guan , *Beijing Univ of Posts & Telecom*

We propose an AI-assisted intent-based traffic grooming scheme in 5G optical access network. The experimental results show scheme achieves autonomous decision-making for service assurance and efficiently optimizes network performance by AI-assisted intent-based traffic grooming.

Authors:Luyao Guan, Beijing Univ of Posts & Telecom / Min Zhang, Beijing Univ of Posts & Telecom / Danshi Wang, Beijing Univ of Posts & Telecom / Chunyu Zhang, Beijing Univ of Posts & Telecom

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5:00 - 5:30 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news

5:30 - 7:30 Pacific Time (US & Canada) (UTC - 07:00)

F2A

Advances of Coherent Technologies

Presider: Frederick Kish

F2A.1

Coherent Optical Communications Using Coherence-Cloned Kerr Soliton Microcombs as Carriers and Local Oscillators

Presenter: Heng Zhou , *Univ of Electronic Science & Tech China*

We demonstrate cloning of two Kerr soliton combs via using the techniques of pump laser conveying and two-point locking. The cloned Kerr combs are used as carriers and local oscillators for coherent optical transmission.

Authors:Yong Geng, Univ of Electronic Science & Tech China / Xinjie Han, Univ of Electronic Science & Tech China / Guangwei Deng, Univ of Electronic Science & Tech China / Qiang Zhou, Univ of Electronic Science & Tech China / Kun Qiu, Univ of Electronic Science & Tech China / Heng Zhou, Univ of Electronic Science & Tech China

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F2A.2

Transmitter-Receiver Optical Sub Assembly Using Ultra-Compact Tunable DBR/Ring Laser

Presenter: Kazuya Nagashima , *Furukawa Electric Co., Ltd.*

We demonstrate a tiny optical module which integrates an ultra-compact wavelength tunable laser, InP-based transmitter and PLC-based receiver. The optical module exhibits low-insertion loss (<13.6 dB) and high bandwidth (>45 GHz) for ≥400-Gb/s coherent-optical links.

Authors:Kazuya Nagashima, Furukawa Electric Co., Ltd. / Yozo Ishikawa, Furukawa Electric Co., Ltd. / Atsushi Izawa, Furukawa Electric Co., Ltd. / Masayoshi Nishita, Furukawa Electric Co., Ltd. / Noritaka Matsubara, Furukawa Electric Co., Ltd. / Hiroyuki Ishii, Furukawa Electric Co., Ltd. / Thanakit Saeyang, Furukawa Fitel Thailand / Yoshihiro Ogiso, NTT Corporation / Yuta Ueda, NTT Corporation / Masaki Kohtoku, Furukawa Electric Co., Ltd.

F2A.3

High-Performance 100Gbaud Coherent Photonic Modules

Invited

Presenter: Mehrdad Ziari , *Infinera Corporation*

1.6 Tb/s optical engine is enabled through vertical integration of a 2-channel monolithic InP PIC with SiGe electronics and a real-time DSP ASIC operating at 100 Gbaud for 800 Gb/s transmission.

Authors:Mehrdad Ziari, Infinera Corporation / Vikrant Lal, Infinera Corporation / Pavel Studenkov, Infinera Corporation / Hossein Hodaei, Infinera Corporation / Thomas Frost, Infinera Corporation / Corey Tsai, Infinera Corporation / Koichi Hoshine, Infinera Corporation / Babak Behnia, Infinera Corporation / Matthias Kuntz, Infinera Corporation / Ryan Going, Infinera Corporation / Stefan Wolf, Infinera Corporation / Stefano Porto, Infinera Corporation / Thomas Vallaitis, Infinera Corporation / Ehsan Sooudi, Infinera Corporation / Justin Lavrencik, Infinera Corporation / Randal Salvatore, Infinera Corporation / Nikhil Modi, Infinera Corporation / Matthew Fisher, Infinera Corporation / Sanjeev Murthy, Infinera Corporation / Payam Abolghasem, Infinera Corporation / Sanketh Buggaveeti, Infinera Corporation / Robert Brigham, Infinera Corporation / Don Pavinski, Infinera Corporation / Jiaming Zhang, Infinera Corporation / Jianping Zhang, Infinera Corporation / Scott Corzine, Infinera Corporation / Peter Evans, Infinera Corporation / Vincent Dominic, Infinera Corporation / Robert Maher, Infinera Corporation / Pierre Mertz, Infinera Corporation / Steve Sanders, Infinera Corporation / Han Henry Sun, Infinera Corporation / John Osenbach, Infinera Corporation / Parthiban Kandappan, Infinera Corporation

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F2A.4

Self-Coherent Single-Sideband Signal Generation by Injection Locking of a 2-Section Laser Diode

Presenter: Rongqing Hui , *University of Kansas*

We propose a low complexity transmitter of optical single-sideband modulation based on injection locking of a 2-section DFB laser to generate mutually-coherent tones. The scheme is experimentally demonstrated in 17-Gbd 16-QAM transmission with Kramers-Kronig reception.

Authors:Rongqing Hui, University of Kansas / Mustafa Al-Qadi, University of Kansas / Charles Laperle, Ciena Corporation / Doug Charlton, Ciena Corporation / Maurice O'Sullivan, Ciena Corporation

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F2A.5

Broadband Dynamic Injection-Locking Performance of Fabry-Perot LD and Its Application to Coherent Homodyne Receiver

Presenter: Keisuke Kasai , *Tohoku University*

We describe the broadband injection-locking performance of a Fabry-Perot LD (FP-LD) whose dynamic locking bandwidth can be greatly extended to 28.8 GHz with a low Q-value FP-LD. Application to 256 QAM demodulation is successfully demonstrated.

Authors:Takashi Kan, Tohoku University / Keisuke Kasai, Tohoku University / Masato Yoshida, Tohoku University / Toshihiko Hirooka, Tohoku University / Masataka Nakazawa, Tohoku University

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F2B

Metamaterial and Multimode Devices for Optical Communications

Presider: Kazuhiro Ikeda

F2B.1

Interfacing Photonics to Free Space via Large-Area Inverse-Designed Diffraction Elements and Metasurfaces

Invited

Presenter: Vladimir Aksyuk , *National Inst of Standards & Technology*

Large-area inverse-designed photonic gratings and optical metasurfaces directly couple waveguides to wide free-space modes with custom wavefronts and polarizations in the visible and near-infrared. Design, modeling methods and experimental results are discussed.

Authors:Alexander Yulaev, National Inst of Standards & Technology / Wenqi Zhu, National Inst of Standards & Technology / Chad Ropp, National Inst of Standards & Technology / Daron Westly, National Inst of Standards & Technology / Gregory Simelgor, National Inst of Standards & Technology / Cheng Zhang, National Inst of Standards & Technology / Henri Lezec, National Inst of Standards & Technology / Amit Agrawal, National Inst of Standards & Technology / Vladimir Aksyuk, National Inst of Standards & Technology

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F2B.2

Ultra-Compact Silicon Mode Converter Based on a Zigzag-Type Metasurface Structure

Presenter: Hongwei Wang , *Shanghai Jiao Tong University*

An ultra-compact silicon waveguide mode converter is proposed and experimentally demonstrated using an all-dielectric metasurface structure with zigzag-type periodic perturbations.

Authors:Hongwei Wang, Shanghai Jiao Tong University / Yu He, Shanghai Jiao Tong University / Lu Sun, Shanghai Jiao Tong University / Yong Zhang, Shanghai Jiao Tong University / Yikai Su, Shanghai Jiao Tong University

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F2B.3

Four-Mode Waveguide Crossing via Digitized Meta-Structure

Presenter: Yingjie Liu , *Harbin Institute of Technology (Shenzhen*

A four-mode waveguide crossing with footprint of only 7.5×7.5 μm^2 is demonstrated on silicon photonic platform. The device insertion loss is less than 0.85 dB, and the crosstalk is below -18 dB for 1500-1580 nm.

Authors:Yingjie Liu, Harbin Institute of Technology (Shenzhen / zhongqiu Zhong, Harbin Institute of Technology (Shenzhen / Shuai Wang, Harbin Institute of Technology (Shenzhen / Yilin Liu, Harbin Institute of Technology (Shenzhen / Yong Yao, Harbin Institute of Technology (Shenzhen / Jiangbing Du, Shanghai Jiao Tong University / Qinghai Song, Harbin Institute of Technology (Shenzhen / Ke Xu, Harbin Institute of Technology (Shenzhen

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F2B.4

Experimental Demonstration of Broadband Silicon 4-Mode (de)Multiplexer Designed by Wavefront-Matching Method

Presenter: Yusuke Sawada , *Hokkaido University*

A broadband silicon-based 4-mode multiplexer designed using a wavefront-matching method is experimentally demonstrated. Measured results strongly correlate with simulated results, and very flat transmission spectra are observed for the proposed device.

Authors:Yusuke Sawada, Hokkaido University / Takeshi Fujisawa, Hokkaido University / Takanori Sato, Hokkaido University / Kunimasa Saitoh, Hokkaido University

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F2B.5

Silicon Nitride Band Splitter Based on Multimode Bragg Gratings

Presenter: Jonathan Cauchon , *Laval University*

We demonstrate a silicon nitride multimode Bragg grating as a C/L diplexer for single-fiber bidirectional communications. The device was fabricated using optical lithography and achieved a channel isolation greater than 20 dB.

Authors:Jonathan Cauchon, Laval University / Jonathan St-Yves, Laval University / Francois Menard, AEPONYX / Wei Shi, Laval University

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F2B.6

Subwavelength Grating Metamaterial Structures for Integrated Photonics

Invited

Presenter: Robert Halir , *Universidad de Malaga*

We report on our advances on the use of subwavelength metamaterials for silicon photonic devices, including narrowband filters, antennas, polarization handling, on-chip beam forming and sensing.

Authors:Robert Halir, Universidad de Malaga / Alejandro Sánchez-Postigo, Universidad de Malaga / Jose Manuel Luque-González, Universidad de Malaga / Abdelfettah Hadij-ElHouati, Universidad de Malaga / Daniel Pereira-Martín, Universidad de Malaga / Jonas Leuermann, Universidad de Malaga / Pablo Ginel-Moreno, Universidad de Malaga / Carlos Pérez-Armenta, Universidad de Malaga / Antonia Torres-Cubillo, Universidad de Malaga / Alaine Herrero-Bermello, Alcyon Photonics / Antonio Dias-Ponte, Alcyon Photonics / David González-Andrade, CSIC / Aitor Villafranca, CSIC / Gonzalo Wangüemert-Pérez, Universidad de Malaga / Alejandro Ortega-Moñux, Universidad de Malaga / José de-Oliva-Rubio, Universidad de Malaga / Pavel Cheben, National Research Council Canada / Jens Schmid, National Research Council Canada / Jiri Ctyroky, Institute of Photonics and Electronics / Milos Nedeljkovic, University of Southampton / Goran Mashanovich, University of Southampton / Íñigo Molina-Fernández, Universidad de Malaga

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F2C

Photodetectors

Presider: Hai-Feng Liu

F2C.1

Monolithic Integration of III-v/Si Hybrid MOS Optical Phase Shifter and InGaAs Membrane Photodetector

Presenter: Shuhei Ohno , *the University of Tokyo*

We present proof-of-concept monolithic integration of III-V/Si hybrid MOS optical phase shifter and InGaAs membrane photodetector for Si programmable photonic integrated circuits. We demonstrated responsivity of > 1.0 A/W at O-band owing to avalanche amplification.

Authors:Shuhei Ohno, the University of Tokyo / Stéphane Monfray, STMicroelectronics / Frederic Boeuf, STMicroelectronics / Kasidit Toprasertpong, the University of Tokyo / Shinichi Takagi, the University of Tokyo / Mitsuru Takenaka, the University of Tokyo

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F2C.2

Butt-Coupled III-v Photodetector Monolithically Integrated on SOI With Data Reception at 50 Gbps OOK

Presenter: Preksha Tiwari , *IBM Research Europe*

We demonstrate the first in-plane waveguide butt-coupled high-speed III-V p-i-n photodetector monolithically integrated on standard SOI and demonstrate data reception at 50 GBd using OOK and a 3 dB cut-off frequency approaching 70 GHz.

Authors:Preksha Tiwari, IBM Research Europe / Pengyan Wen, IBM Research Europe / Svenja Mauthe, IBM Research Europe / Michael Baumann, ETH Zurich / Bertold Bitachon, ETH Zurich / Schmid Heinz, IBM Research Europe / Juerg Leuthold, ETH Zurich / Kirsten Moselund, IBM Research Europe

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F2C.3

Recess-Type Waveguide Integrated Germanium on Silicon Avalanche Photodiode

Presenter: Mengyuan Huang , *Intel Corporation*

We demonstrate a recess-type Ge on Si WGAPD receiver with 106Gb/s PAM4 overload >0dBm and unstressed/stressed sensitivities of -18.9/18dBm, which provides about 19dB dynamic range for 100Gb/s per lane applications.

Authors:Mengyuan Huang, Intel Corporation / Kelly Magruder, Intel Corporation / Yann Malinge, Intel Corporation / Parastou Fakhimi, Intel Corporation / Hao-Hsiang Liao, Intel Corporation / David Kohen, Intel Corporation / Gregory Lovell, Intel Corporation / Wei Qian, Intel Corporation / Kiyoung Lee, Intel Corporation / Carsten Brandt, Intel Corporation / Mahtab Hakami, Intel Corporation / Yen-jung Chen, Intel Corporation / Erin Carabajal, Intel Corporation / Erle Guillermo, Intel Corporation / Seth Slavin, Intel Corporation / Ansheng Liu, Intel Corporation

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F2C.4

High Speed and Low Dark Current InGaAs Photodiodes on CMOS-Compatible Silicon by Heteroepitaxy

Presenter: Bowen Song , *University of California Santa Barbara*

High speed InGaAs photodiodes were realized on (001) Si by direct heteroepitaxy, demonstrating low dark current, high responsivity, a bandwidth of 11 GHz and up to 30 Gbps operation at a wavelength of 1550 nm.

Authors:Bowen Song, University of California Santa Barbara / Bei Shi, University of California Santa Barbara / Si Zhu, University of California Santa Barbara / Simone Brunelli, University of California Santa Barbara / Jonathan klamkin, University of California Santa Barbara

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F2C.5

High-Speed and High Saturation Power Avalanche Photodiode for Coherent Communication

Presenter: None Naseem , *National Central University*

High-speed/power APDs with novel etched-mesa structure are demonstrated to suppress edge breakdown. With 24mm diameters, they achieve 21GHz bandwidths, 5.5A/W responsivity, and RF saturation power over +5 dBm (10 GHz) under 8mA photocurrent and $0.9V_{br}$

Authors:None Naseem, National Central University / Sean Yang, Source Photonics / Sheng-Yun Wang, Source Photonics / Hsiang-Szu Chang, Source Photonics / H.-S. Chen, Source Photonics / Jack Jia-Sheng Huang, Source Photonics / Emin Chou, Source Photonics / Yu-Heng Jan, Source Photonics / Jin-Wei Shi, National Central University

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F2C.6

InP-Based PIC Integrated With Butt-Joint Coupled Waveguide p-i-n PDs for 100GBaud Coherent Networks

Presenter: Takuya Okimoto , *Sumitomo Electric Industries, Ltd.*

InP-based PICs with waveguide p-i-n PDs for 100 GBaud coherent receivers are demonstrated. The wide 3-dB bandwidth of more than 65 GHz and high responsivity of 0.154 A/W are revealed at a wavelength of 1.55 μm. We successfully achieve the monolithic integration of 19 functions as InP-based PICs with a footprint of 10.7 mm^2.

Authors:Takuya Okimoto, Sumitomo Electric Industries, Ltd. / Hideki Yagi, Sumitomo Electric Industries, Ltd. / Koji Ebihara, Sumitomo Electric Device Innovations, Inc. / Kouichiro Yamazaki, Sumitomo Electric Device Innovations, Inc. / Satoru Okamoto, Sumitomo Electric Device Innovations, Inc. / Yusuke Ohkura, Sumitomo Electric Device Innovations, Inc. / Kazuhiko Horino, Sumitomo Electric Device Innovations, Inc. / Ken Ashizawa, Sumitomo Electric Device Innovations, Inc. / Mitsuru Ekawa, Sumitomo Electric Industries, Ltd. / Yoshihiro Yoneda, Sumitomo Electric Industries, Ltd.

F2C.7

Dual M-Layers Avalanche Photodiodes With Extremely Wide Dynamic Ranges and Ultra-High Bandwidth-Responsivity Product Performances in FMCW Lidar Systems

Presenter: Zohauddin Ahmad , *National Central University*

Dual multiplication-layers APDs with large bandwidth-responsivity product (460GHz-A/W), saturation-current (>10mA), and IF-power (+4.5dBm) are demonstrated in self-heterodyne FWCW lidar systems with ~285% modulation depths. Constructed images show 9.5dB larger SNRs than that of p-i-n PD.

Authors:Zohauddin Ahmad, National Central University / Yan-Min Liao, National Central University / Sheng-I Kuo, Nationl Chiao Tung University / You-Chia Chang, Nationl Chiao Tung University / Rui-Lin Chao, National Central University / None Naseem, National Central University / Yi-Shan Lee, National Central University / Jin-Wei Shi, National Central University

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F2D

High-speed Direct Detection Demonstrations

Presider: Fan Zhang

F2D.1

120 GSa/s BiCMOS Analog Multiplexer Enabling 360 Gbit/s DSCM-PCS-256QAM IM/DD Transmission

Presenter: Qian Hu , *Nokia Bell Labs*

Generation of real-valued digital-subcarrier-multiplexed PCS-256QAM is demonstrated using a 120 GSa/s BiCMOS analog multiplexer. A record per-modulation-dimension spectral efficiency of 3 bit/s/Hz is achieved supporting a net data rate of 360 Gbit/s after 10 km IM/DD transmission.

Authors:Qian Hu, Nokia Bell Labs / Karsten Schuh, Nokia Bell Labs / Michael Collisi, Saarland University / Vahid Aref, Nokia Bell Labs / Horst Hettrich, Micram Microelectronic GmbH / Rolf Schmid, Micram Microelectronic GmbH / Fred Buchali, Nokia Bell Labs / Michael Möller, Saarland University

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F2D.2

147-Gb/s Transmission of Optical Single Sideband DMT Signal Generated by Dual Modulation of DML and EAM

Presenter: Tianwai Bo , *Korea Advanced Inst of Science & Tech*

We experimentally demonstrate a record transmission of 147-Gb/s (net 122-Gb/s) optical single sideband discrete multi-tone signal, generated by modulating both a directly modulated laser and an electro-absorption modulator, over an 80-km C-band link.

Authors:Tianwai Bo, Korea Advanced Inst of Science & Tech / Hoon Kim, Korea Advanced Inst of Science & Tech

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F2D.3

Advanced Nonlinear Digital Signal Processing for Short-Reach Applications

Invited

Presenter: xiang li , *University of Cambridge*

In this paper, we discuss different nonlinear impairments in short-reach fibre transmission systems. Recent progress on the nonlinear digital signal processing techniques to mitigate such nonlinear impairments are summarized.

Authors:xiang li, University of Cambridge / Md Saifuddin Faruk, University of Cambridge / Seb Savory, University of Cambridge

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F2D.4

320Gb/s Nyquist-Shaped Twin SSB 16-QAM Signal Transmission Over 80km SSMF With a Silicon IQ Modulator

Presenter: Fan Yang , *Peking University*

We experimentally demonstrate ultrahigh speed metro-haul optical transmission of twin SSB 16-QAM signal with a Silicon IQ modulator. A 320Gb/s data rate over 80km SSMF is achieved with a BER below the 20% SD-FEC threshold.

Authors:Fan Yang, Peking University / Lei Zhang, Peking University / Xinyu Chen, Peking University / Xiansong Fang, Peking University / Chenjia Li, Peking University / Fan Zhang, Peking University

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F2D.5

465 Gbps Single Side Band Direct Detection Transmission Over 40 km of SSMF Using a Single-Ended Photodiode

Presenter: Son Le , *Nokia Bell Labs*

We propose a novel adaptive algorithm to mitigate simultaneously the O/E front-end response and the SSBI in SSB direct detection transmissions and demonstrate a net data rate of 465 Gb/s over 40 km of SSMF using a single-ended photodiode

Authors:Son Le, Nokia Bell Labs / Karsten Schuh, Nokia Bell Labs

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F2D.6

Experimental Comparison of Uniform and Probabilistically Shaped PAM-8 for IMDD System at Transmission Rates Beyond 200 Gbit/s

Presenter: Md Sabbir-Bin Hossain , *Huawei Technologies*

We have experimentally shown that probabilistically shaped PAM-8 improves receiver sensitivity by more than 1 dB compared with regular PAM-8 for data rates beyond 200 Gbit/s.

Authors:Md Sabbir-Bin Hossain, Huawei Technologies / Talha Rahman, Huawei Technologies / Georg Böcherer, Huawei Technologies / Nebojsa Stojanovic, Huawei Technologies / Tom Wettlin, Kiel University / Stefano Calabro, Huawei Technologies / Jinlong Wei, Huawei Technologies / Changsong Xie, Huawei Technologies / Stephan Pachnicke, Kiel University

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F2E

Quantum and Novel Subsystems

Presider: Ana Pejkic

F2E.1

Microresonator Brillouin Laser Gyroscope With Earth-Rotation-Rate Sensitivity

Invited

Presenter: Myoung-Gyun Suh , *NTT Research*

Optical gyroscopes are widely used for precision navigation and there has been growing interest in the possibility of integrated optical gyroscopes. In this talk, we report a chip-based Brillouin laser gyroscope with Earth-rotation-rate sensitivity.

Authors:Myoung-Gyun Suh, NTT Research / Yu-Hung Lai, OEwaves / Kerry Vahala, California Institute of Technology

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F2E.2

Simplifying Measurement-Device-Independent Quantum Key Distribution With Directly Modulated Laser Sources

Presenter: Robert Woodward , *Toshiba Research Europe Ltd.*

We demonstrate a new MDI-QKD system design employing gain-switched, injection-locked lasers to directly generate GHz-clock-rate encoded states, greatly simplifying MDI-QKD and improving state-of-the-art performance by an order of magnitude.

Authors:Robert Woodward, Toshiba Research Europe Ltd. / Yuen San Lo, Toshiba Research Europe Ltd. / Mirko Pittaluga, Toshiba Research Europe Ltd. / Mariella Minder, Toshiba Research Europe Ltd. / Taofiq Paraiso, Toshiba Research Europe Ltd. / Marco Lucamarini, Toshiba Research Europe Ltd. / Zhiliang Yuan, Toshiba Research Europe Ltd. / Andrew Shields, Toshiba Research Europe Ltd.

F2E.3

Novel Link Architecture Minimizing Thermal Energy Dissipation for Cryogenic Optical Interconnects

Presenter: Steven Estrella , *Freedom Photonics*

A novel cryogenic optical interconnect architecture and first demonstration is presented, using external laser tracking and ring resonator modulators – that provide both modulation and wavelength multiplexing – for scalable cryogenic interconnects with minimized thermal energy dissipation.

Authors:Steven Estrella, Freedom Photonics / Thomas Dorch, Freedom Photonics / Trevor Cooper, Freedom Photonics / Aaron Maharry, University of California Santa Barbara / Takako Hirokawa, University of California Santa Barbara / Daniel Renner, Freedom Photonics / Clint Schow, University of California Santa Barbara

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F2E.4

Synchronization of Electro-Optically Modulated Kerr Soliton Comb to a Chip-Scale Mode-Locked Laser PIC via Harmonic Injection Locking

Presenter: Chinmay Shirpurkar , *CREOL, The College of Optics & Photonics*

We present an optical frequency division technique to transfer the timing stability of a stabilized Kerr Microresonator Soliton Frequency Comb (~305 GHz repetition rate) to a chip-scaled mode-locked laser (~10 GHz repetition rate).

Authors:Chinmay Shirpurkar, CREOL, The College of Optics & Photonics / Ricardo Bustos-Ramirez, CREOL, The College of Optics & Photonics / Lawrence Trask, CREOL, The College of Optics & Photonics / Srinivas Pericherla, CREOL, The College of Optics & Photonics / Travis Briles, National Institute for Standards and Technology / Jordan Stone, National Institute for Standards and Technology / Su-Peng Yu, National Institute for Standards and Technology / Ashish Bhardwaj, Infinera Corporation / Gloria Hoefler, Infinera Corporation / Scott Papp, National Institute for Standards and Technology / Peter Delfyett, CREOL, The College of Optics & Photonics

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F2E.5

All-Optical Bi-Directional Polarization Demultiplexing for Self-Homodyne Coherent Detection

Presenter: Yizhao Chen , *Huazhong University of Science and Technology*

An all-optical bi-directional polarization demultiplexing self-homodyne coherent system is proposed. In the 120-Gbit/s 16-QAM experimental demonstration, one adaptive polarization controller is applied to lock the polarization of uplink and downlink light at the same time.

Authors:Yizhao Chen, Huazhong University of Science and Technology / Xuefeng Wang, Huazhong University of Science and Technology / Yifan Zeng, Huazhong University of Science and Technology / Junda Chen, Huazhong University of Science and Technology / Weihao Li, Huazhong University of Science and Technology / Yao Zhang, Huazhong University of Science and Technology / Mingming Zhang, Huazhong University of Science and Technology / Can Zhao, Huazhong University of Science and Technology / Ming Tang, Huazhong University of Science and Technology / deming liu, Huazhong University of Science and Technology

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F2E.6

Optical Arbitrary Waveform Measurement (OAWM) on the Silicon Photonic Platform

Presenter: Dengyang Fang , *Karlsruhe Institute of Technology*

We demonstrate optical arbitrary waveform measurement (OAWM) with a silicon photonic spectral slicer. Exploiting maximal-ratio combining (MRC), we demonstrate the viability of the scheme for reconstruction of 100-GBd 64QAM signals.

Authors:Dengyang Fang, Karlsruhe Institute of Technology / Andrea Zazzi, RWTH Aachen University / Juliana Müller, RWTH Aachen University / Daniel Drayß, Karlsruhe Institute of Technology / Christoph Füllner, Karlsruhe Institute of Technology / Pablo Marin-Palomo, Karlsruhe Institute of Technology / Alireza Tabatabaei Mashayekh, RWTH Aachen University / Arka Das, RWTH Aachen University / Maxim Weizel, University of Paderborn / Sergiy Gudyriev, University of Paderborn / Wolfgang Freude, Karlsruhe Institute of Technology / Sebastian Randel, Karlsruhe Institute of Technology / Christoph Scheytt, University of Paderborn / Jeremy Witzens, RWTH Aachen University / Christian Koos, Karlsruhe Institute of Technology

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F2E.7

Simultaneous Generation of 16×10 Gb/s WDM Channels Using a Single a-Si Waveguide Based Time Lens Source

Presenter: Xiaoyu Xu , *Technical University of Denmark*

We generate 16×10 Gb/s channels from a 160 Gb/s OTDM signal using an amorphous silicon waveguide based time-lens. All channels achieve BER < 10^{-9}.

Authors:Xiaoyu Xu, Technical University of Denmark / Peter Girouard, Technical University of Denmark / Mads Lillieholm, Technical University of Denmark / Lars Emil Gutt, Technical University of Denmark / Lars H.Frandsen, Technical University of Denmark / Leif Oxenløwe, Technical University of Denmark / Pengyu Guan, Technical University of Denmark

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F2F

Co-packaged Optics and Disaggregated Data-center Architectures

Presider: Fotini Karinou

F2F.1

Current State and Outlook on High-Bandwidth in-Package Optics

Invited

Presenter: Mark Wade , *Ayar Labs*

Abstract not available.

Authors:Mark Wade, Ayar Labs

F2F.2

Silicon Photonic Based Stacked Die Assembly for 4×200-Gbit/s Short-Reach Transmission

Presenter: Ying Zhao , *Acacia Communication Inc.*

We present a silicon photonic based stacked die assembly with driver and transimpedance amplifier for 4×200-Gbps applications. Various 200-Gbps pulse amplitude modulation formats over 2 and 10.5-km transmissions are demonstrated and compared.

Authors:Ying Zhao, Acacia Communication Inc. / Li Chen, Acacia Communication Inc. / Ricardo Aroca, Acacia Communication Inc. / Ninghui Zhu, Acacia Communication Inc. / Dinh Ton, Acacia Communication Inc. / David Inglis, Acacia Communication Inc. / Chris Doerr, Acacia Communication Inc.

F2F.3

10Gb/s Intra-Chip Compact Electro-Optical Interconnect

Presenter: Marco Eppenberger , *Institute of Electromagnetic Fields (IEF), ETH Zurich*

We demonstrate a digital-to-optical-to-digital link operating at 10 Gb/s with 2.4 pJ/b below 10^{-9} BER enabled by zero-change CMOS macros. All necessary electronic-photonic circuits are contained within 0.015 mm^2 of silicon area.

Authors:Marco Eppenberger, Institute of Electromagnetic Fields (IEF), ETH Zurich / Mattia Bonomi, Integrated Systems Laboratory (IIS), ETH Zurich / David Moor, Institute of Electromagnetic Fields (IEF), ETH Zurich / Marco Mueller, Integrated Systems Laboratory (IIS), ETH Zurich / Bertold Bitachon, Institute of Electromagnetic Fields (IEF), ETH Zurich / Thomas Burger, Integrated Systems Laboratory (IIS), ETH Zurich / Luca Alloatti, Institute of Electromagnetic Fields (IEF), ETH Zurich

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F2F.4

Optical Switching for Memory-Disaggregated Datacenters

Invited

Presenter: Nicola Calabretta , *Technische Universiteit Eindhoven*

Nanoseconds WDM optical switch is exploited to implement a rack-scale memory disaggregated datacenter network (DCN). Numerical and experimental results validate the disaggregated DCN architecture prototype with 122.3ns network latency, zero packet loss, and error-free operation.

Authors:Nicola Calabretta, Technische Universiteit Eindhoven / Xiaotao Guo, Technische Universiteit Eindhoven / Georgios Exarchakos, Technische Universiteit Eindhoven / Xuwei Xue, Technische Universiteit Eindhoven / Bitao Pan, Technische Universiteit Eindhoven

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F2F.5

Bi-Directional Interleaved Sub-Band Amplification in DWDM Application Using Single Unidirectional EDFA and 8×8 Cyclic-AWG

Presenter: Ziyu Cheng , *Shanghai Jiao Tong University*

A bi-directional optical amplification scheme based on single unidirectional EDFA and 8×8 Cyclic-AWG is presented, which has >10dB maximum gain and the additional ROP penalty at 50Gbit/s PAM-4 is ~1dB compared to EDFA amplification only.

Authors:Ziyu Cheng, Shanghai Jiao Tong University / Zidong Guo, Shanghai Jiao Tong University / Yixiao Zhu, Shanghai Jiao Tong University / Weisheng Hu, Shanghai Jiao Tong University

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F2G

Machine Learning and Data Analytics for Autonomous Network Operation

Presider: António Eira

F2G.1

Reliable and Accurate Autonomous Flow Operation Based on Off-Line Trained Reinforcement Learning

Presenter: Sima Barzegar , *Universitat Politecnica de Catalunya*

A RL agent trained offline for reliability and able to refine its policies during online operation is proposed. Results for three illustrative flow automation use cases show remarkable performance with extraordinary adaptability to changes.

Authors:Sima Barzegar, Universitat Politecnica de Catalunya / Marc Ruiz, Universitat Politecnica de Catalunya / Luis Velasco, Universitat Politecnica de Catalunya

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F2G.2

Node-Oriented Traffic Prediction and Scheduling Based on Graph Convolutional Network in Metro Optical Networks

Presenter: Bowen Bao , *Beijing University of Posts and Telecommunications*

This paper proposes a node-oriented traffic prediction and scheduling in elastic metro optical networks by introducing the graph convolution network. Simulation results show the proposed scheme achieves efficient resource utilization with an accurate traffic prediction.

Authors:Bowen Bao, Beijing University of Posts and Telecommunications / Hui Yang, Beijing University of Posts and Telecommunications / Yu Wan, Beijing University of Posts and Telecommunications / Qiuyan Yao, Beijing University of Posts and Telecommunications / Ao Yu, Beijing University of Posts and Telecommunications / Jie Zhang, Beijing University of Posts and Telecommunications / Bijoy Chatterjee, South Asian University / Eiji Oki, Kyoto University

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F2G.3

A Machine Learning Framework for Scalable Routing and Wavelength Assignment in Large Optical Networks

Invited

Presenter: Andrea Bianco , *Politecnico di Torino*

We perform a machine-learning-based network pruning that significantly reduces the complexity of routing and wavelength assignment in large optical networks. A significant computational time reduction is achieved by accepting a minor deterioration of the obtained solution.

Authors:Davide Andreoletti, SUPSI / Cristina Rottondi, Politecnico di Torino / Andrea Bianco, Politecnico di Torino / Silvia Giordano, SUPSI

F2G.4

Combining Long-Short Term Memory and Reinforcement Learning for Improved Autonomous Network Operation

Presenter: Fatemehsadat Tabatabaeimehr , *Universitat Politecnica de Catalunya*

A combined LSTM and RL approach is proposed for dynamic connection capacity allocation. The LSTM predictor anticipates periodical long-term sharp traffic changes and extends short-term RL knowledge. Numerical results show remarkable performance.

Authors:Fatemehsadat Tabatabaeimehr, Universitat Politecnica de Catalunya / Sima Barzegar, Universitat Politecnica de Catalunya / Marc Ruiz, Universitat Politecnica de Catalunya / Luis Velasco, Universitat Politecnica de Catalunya

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F2G.5

Real-Time Control Plane Operations for GOSNR QoT Estimation Through OSNR Monitoring

Presenter: Alan Díaz Montiel , *CONNECT Centre, Trinity College Dublin*

We analyze an optical control plane algorithm designed to operate in real-time to improve generalized-optical signal-to-noise ratio (gOSNR) quality-of-transmission-estimation (QoT-E), based on OSNR monitoring. We report QoT-E performance improvements of up to 1 dB.

Authors:Alan Díaz Montiel, CONNECT Centre, Trinity College Dublin / Ayush Bhardwaj, CONNECT Centre, Trinity College Dublin / Bob Lantz, University of Arizona / Jiakai Yu, University of Arizona / Aamir Quraishy, University of Arizona / Daniel Kilper, University of Arizona / Marco Ruffini, CONNECT Centre, Trinity College Dublin

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F2G.6

Self-Adaptive Network Monitoring in IP-Over-EONs: When Multilayer Telemetry is Flexible and Driven by Data Analytics

Presenter: Shaofei Tang , *Univ of Science and Technology of China*

We propose and experimentally demonstrate a self-adaptive network monitoring system for IP over elastic optical networks, which can coordinate and adjust in-band and out-of-band monitoring schemes intelligently based on the data analytics on multilayer telemetry data.

Authors:Shaofei Tang, Univ of Science and Technology of China / Jianquan Peng, Univ of Science and Technology of China / Siqi Liu, Univ of Science and Technology of China / Jiawei Kong, Univ of Science and Technology of China / Zuqing Zhu, Univ of Science and Technology of China

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F2H

High Capacity PON, 100Gb/s and Beyond

Presider: Elaine Wong

F2H.1

Use of Pons for High-Capacity, Low Latency Services

Tutorial

Presenter: Thomas Pfeiffer , *Nokia Bell Labs*

Initially designed for best effort broadband services to residential customers, PONs are now considered also for x-haul, and for deterministic services in vertical markets. This tutorial provides insights into related service requirements and PON capabilities.

Authors:Thomas Pfeiffer, Nokia Bell Labs

F2H.2

First Experimental Demonstration of Flexible Rate PON Beyond 100Gb/s With Probabilistic and Geometric Shaping

Presenter: Noriaki Kaneda , *Nokia Bell Labs*

The pairwise probabilistic combined with geometric shaping is applied to IMDD system. With shaped PAM signals, the flexible information rate beyond 100Gb/s is experimentally demonstrated for the first time in a practical PON link.

Authors:Noriaki Kaneda, Nokia Bell Labs / Rui Zhang, Nokia Bell Labs / Yannick Lefevre, Nokia Bell Labs / Amitkumar Mahadevan, Nokia Bell Labs / Dora van Veen, Nokia Bell Labs / Vincent Houtsma, Nokia Bell Labs

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F2H.3

Spectrally Efficient Downstream 100 Gb/s PolMux Multi-CAP OSSB Transmission and Coherent Reception Using 10G Electronics for Passive Optical Networks

Presenter: Miguel Barrio , *Universidad de Zaragoza*

We present a 100Gb/s downstream PON link based on a PolMux, multi-CAP OSSB modulation signal received by a coherent receiver. 50km transmission is achieved using 10G electronic and photonic devices with a sensitivity of -20dBm.

Authors:Miguel Barrio, Universidad de Zaragoza / David Izquierdo, Universidad de Zaragoza / Josep Cerda, Universitat Politècnica de Catalunya / Samael Sarmiento, ICFO / Jose Altabas, Bifrost Communications / Jose Lazaro, Universitat Politècnica de Catalunya / Ignacio Garcés, Universidad de Zaragoza

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F2H.4

Carrier-Recovery-Free KK Detection for PDM-Bipolar-PAM in 100 Gb/s Simplified Coherent PON

Presenter: Haiyun Xin , *Shanghai Jiao Tong University*

We propose and demonstrate, for the first time, carrier-recovery-free KK detection for a PDM-bipolar-PAM signal in simplified coherent TDM-PON. 32 dB power budget is achieved for the 100-Gbps signal after 25km downstream transmission.

Authors:Haiyun Xin, Shanghai Jiao Tong University / xiaoling zhang, Technical University of Denmark / deming kong, Technical University of Denmark / shi jia, Technical University of Denmark / Weisheng Hu, Shanghai Jiao Tong University / Hao Hu, Technical University of Denmark

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F2H.5

Inter-Band Interference Cancellation Based on Independent Component Analysis for 200Gb/s/λ Non-Orthogonal m-CAP NGFI-II Data Transmission in 5G Fronthaul

Presenter: Yinaer Ha , *Fudan University*

We experimentally demonstrated 200Gb/s/λ mobile fronthaul NGFI-II data transmission based on non-orthogonal-m-CAP system. A novel inter-band interference cancellation method based on independent component analysis is proposed to achieve 13% SE improvement.

Authors:Yinaer Ha, Fudan University / Ming Luo, State Key Laboratory of Optical Communication Technologies and Networks, China Information Communication Technologies Group Corporation / Zhixue He, State Key Laboratory of Optical Communication Technologies and Networks, China Information Communication Technologies Group Corporation / Junwen Zhang, Fudan University / Fangchen Hu, Fudan University / Zhe Wang, Fudan University / Nan Chi, Fudan University

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8:00 - 9:00 Pacific Time (US & Canada) (UTC - 07:00)

Special Event - Virtual Fun Run

8:00 - 9:15 Pacific Time (US & Canada) (UTC - 07:00)

F3B

Postdeadline Papers 2

Presider: Ramon Casellas

F3B.1

BOW: First Real-World Demonstration of a Bayesian Optimization System for Wavelength Reconfiguration

Presenter: Zhizhen Zhong , *Massachusetts Institute of Technology*

We demonstrate a practical Bayesian Optimization system for wavelength reconfiguration at Facebook backbone. Our system uses a firewall for safe deployment. It is open-source, compatible with any vendor, and achieves 4.76x faster wavelength reconfiguration.

Authors:Zhizhen Zhong, Massachusetts Institute of Technology / Manya Ghobadi, Massachusetts Institute of Technology / Maximilian Balandat, Facebook / Sanjeevkumar Katti, Facebook / Abbas Kazerouni, Facebook / Jonathan Leach, Facebook / Mark McKillop, Facebook / Ying Zhang, Facebook

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F3B.2

Field Trial of Vibration Detection and Localization Using Coherent Telecom Transponders Over 380-km Link

Presenter: Ezra Ip , *NEC Laboratories America*

We demonstrate vibration detection and localization based on extracting optical phase from the DSP elements of a coherent receiver in bidirectional WDM transmission of 200-Gb/s DP-16QAM over 380 km of installed field fiber.

Authors:Glenn Wellbrock, Verizon Communications Inc / Tiejun Xia, Verizon Communications Inc / Ezra Ip, NEC Laboratories America / Yue-Kai Huang, NEC Laboratories America / Ming-Fang Huang, NEC Laboratories America / Ting Wang, NEC Laboratories America / Yoshiaki Aono, NEC Corporation

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F3B.3

319 Tb/s Transmission Over 3001 km With S, C and L Band Signals Over >120nm Bandwidth in 125 µm Wide 4-Core Fiber

Presenter: Benjamin Puttnam , *National Inst Info & Comm Tech (NICT)*

We demonstrate recirculating transmission of 552 x 25 GHz spaced channels covering >120 nm of S, C and L-bands in a 125µm dimater, 4-core fiber, measuring a decoded throughput of 319 Tb/s at 3001 km

Authors:Benjamin Puttnam, National Inst Info & Comm Tech (NICT) / Ruben Luis, National Inst Info & Comm Tech (NICT) / Georg Rademacher, National Inst Info & Comm Tech (NICT) / Yoshinari Awaji, National Inst Info & Comm Tech (NICT) / Hideaki Furukawa, National Inst Info & Comm Tech (NICT)

F3B.4

Real-Time Transoceanic Coupled 4-Core Fiber Transmission

Presenter: Shohei Beppu , *KDDI Research, Inc.*

We report the first experimental demonstration of transoceanic distance real-time transmission over coupled multicore fibers. The WDM DP-QPSK signals were transmitted over 7,200-km coupled-core four-core fibers by a recirculating loop and demodulated by real-time MIMO DSP.

Authors:Shohei Beppu, KDDI Research, Inc. / Masahiro Kikuta, NEC Platforms, Ltd. / Koji Igarashi, Osaka University / Hiroshi Mukai, NEC Platforms, Ltd. / Masahiro Shigihara, NEC Platforms, Ltd. / Yasuo Saito, NEC Platforms, Ltd. / Daiki Soma, KDDI Research, Inc. / Hidenori Takahashi, KDDI Research, Inc. / Noboru Yoshikane, KDDI Research, Inc. / Itsuro Morita, KDDI Research, Inc. / Masatoshi Suzuki, KDDI Research, Inc.

F3B.5

Ultra-Long-Haul WDM Transmission in a Reduced Inter-Modal Interference NANF Hollow-Core Fiber

Presenter: Pierluigi Poggiolini , *Politecnico di Torino*

We report new transmission distance records through hollow-core NANF with reduced inter-modal interference. We recirculated 41xPM-QPSK C-band channels @32GBaud up to 2070km with average GMI 3.64 bits/symb. For select channels we reached beyond 5000km.

Authors:Antonino Nespola, Links Foundation / Seyed Reza Sandoghchi, Lumenisity Ltd / Lucy Hooper, Lumenisity Ltd / Marcelo Alonso, Lumenisity Ltd / Thomas Bradley, University of Southampton / Hesham Sakr, University of Southampton / Gregory Jasion, University of Southampton / Eric Numkam Fokoua, University of Southampton / Stefano Straullu, Links Foundation / Francesco Garrisi, Links Foundation / Gabriella Bosco, Politecnico di Torino / Andrea Carena, Politecnico di Torino / Margareth Rosa Brusin, Politecnico di Torino / Yong Chen, University of Southampton / John Hayes, University of Southampton / Fabrizio Forghieri, CISCO Photonics / David Richardson, University of Southampton / Francesco Poletti, University of Southampton / Pierluigi Poggiolini, Politecnico di Torino

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8:00 - 9:30 Pacific Time (US & Canada) (UTC - 07:00)

F3A

Postdeadline Papers 1

Presider: Ming-Jun Li

F3A.1

Wide and Parallel LED-Based Optical Links Using Multi-Core Fiber for Chip-to-Chip Communications

Presenter: Bardia Pezeshki , *AvicenaTech Corp.*

We demonstrate >200 optical lanes in 0.5mm diameter imaging fiber with a speed-optimized GaN LED array, and independently, NRZ links of each LED to 10Gb/s over meters, extrapolating to >2Tb/s at a density >10Tb/mm^2.

Authors:Bardia Pezeshki, AvicenaTech Corp. / Alex Tselikov, AvicenaTech Corp. / Robert Kalman, AvicenaTech Corp. / cameron Danesh, AvicenaTech Corp.

F3A.2

Record High-Order Mode-Division-Multiplexed Transmission on Chip Using Gradient-Duty-Cycle Subwavelength Gratings

Presenter: Yu He , *Shanghai Jiao Tong University*

We demonstrate 16-channel mode (de)multiplexers on a silicon chip using gradient duty cycle subwavelength gratings. A 1.51-Tbit/s/polarization/wavelength capacity is achieved at 1550 nm with 7 neighboring 50-GHz spaced ASE channels.

Authors:Yu He, Shanghai Jiao Tong University / Shaohua An, Shanghai Jiao Tong University / Xingfeng Li, Shanghai Jiao Tong University / Yetian Huang, Shanghai University / Yong Zhang, Shanghai Jiao Tong University / Haoshuo Chen, Nokia Bell Labs / Yikai Su, Shanghai Jiao Tong University

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F3A.3

Long-Term Reliable >200-Gb/s Directly Modulated Lasers With 800GbE-Compliant DSP

Presenter: Di Che , *Nokia Bell Labs*

We demonstrate the long-term reliable operation of a 70-GHz-class DFB+R laser and its capability of 108-GBd PAM-4 signaling under +4.8-ps/nm dispersion with ultra-low complexity equalizations as well as faster-than-Nyquist PAM-2 signaling up to 280 GBd.

Authors:Di Che, Nokia Bell Labs / Yasuhiro Matsui, II-VI Incorporated / Richard Schatz, KTH Royal Institute of Technology / Gregory Raybon, Nokia Bell Labs / Vipul Bhatt, II-VI Incorporated / Martin Kwakernaak, II-VI Incorporated / Tsurugi Sudo, II-VI Incorporated

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F3A.4

Hollow Core NANFs With Five Nested Tubes and Record Low Loss at 850, 1060, 1300 and 1625nm

Presenter: Francesco Poletti , *University of Southampton*

Using hollow-core NANFs with 5-nested-tubes, we achieve the lowest loss ever reported in a hollow core fiber at 1300 and 1625nm (0.22dB/km), and in any type of optical fiber at 850nm (0.6dB/km) and 1060nm (0.3dB/km).

Authors:Hesham Sakr, University of Southampton / Thomas Bradley, University of Southampton / Gregory Jasion, University of Southampton / Eric Rodrigue Numkam Fokoua, University of Southampton / Seyed Reza Sandoghchi, Lumenisity ltd / Ian Davidson, University of Southampton / Austin Taranta, University of Southampton / Gianluca Guerra, University of Southampton / William Shere, University of Southampton / Yong Chen, University of Southampton / John Hayes, University of Southampton / David Richardson, University of Southampton / Francesco Poletti, University of Southampton

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F3A.5

Overcoming the Quantum Noise Limit With Continuous-Wave Phase-Sensitive Parametric Amplification Based on a Single Integrated Silicon-Nitride Waveguide

Presenter: PING ZHAO , *Chalmers University of Technology*

We demonstrate continuous-wave phase-sensitive optical parametric amplification with 9.5 dB gain and a 1.2 dB noise figure, well below the conventional 3 dB quantum limit, using a single compact and dispersion-engineered integrated nonlinear Si_3N_4 waveguide.

Authors:PING ZHAO, Chalmers University of Technology / Zhichao Ye, Chalmers University of Technology / Magnus Karlsson, Chalmers University of Technology / Victor Torres-Company, Chalmers University of Technology / Peter Andrekson, Chalmers University of Technology

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F3C

Postdeadline Papers 3

Presider: Christopher Cole

F3C.1

Transparent Optical-THz-Optical Link Transmission Over 5/115 m at 240/190 Gbit/s Enabled by Plasmonics

Presenter: Yannik Horst , *IEF ETHZ*

The first transparent Optical-THz-Optical link providing record-high line-rates up to 240 and 190 Gbit/s over distances from 5 to 115m is demonstrated. The link is based on direct data-conversion from optical to sub-THz and vice-versa.

Authors:Yannik Horst, IEF ETHZ / Tobias Blatter, IEF ETHZ / Laurenz Kulmer, IEF ETHZ / Bertold Bitachon, IEF ETHZ / Benedikt Baeuerle, Polariton Technologies / Marcel Destraz, Polariton Technologies / Wolfgang Heni, Polariton Technologies / Stefan Koepfli, IEF ETHZ / patrick habegger, Polariton Technologies / Marco Eppenberger, IEF ETHZ / Eva De Leo, Polariton Technologies / Claudia Hoessbacher, Polariton Technologies / Delwin Elder, Nonlinear Materials Corporation / Scott Hammond, Nonlinear Materials Corporation / Lewis Johnson, Nonlinear Materials Corporation / Yuriy Fedoryshyn, IEF ETHZ / Yannick Salamin, MIT / Maurizio Burla, IEF ETHZ / Juerg Leuthold, IEF ETHZ

F3C.2

Field Demonstration of Real-Time 14 Tb/s 220 m FSO Transmission With Class 1 Eye-Safe 9-Aperture Transmitter

Presenter: Keisuke Matsuda , *Mitsubishi Electric Corporation*

We demonstrated a 9-aperture transmit and single aperture receive FSO system transmitting 35-WDM 400 Gb/s DP-PS-16-QAM signals over 220 m. By splitting the WDM signals into 9 groups, eye-safe transmit power density was enabled.

Authors:Keisuke Matsuda, Mitsubishi Electric Corporation / Masashi Binkai, Mitsubishi Electric Corporation / Shota Koshikawa, Mitsubishi Electric Corporation / Tsuyoshi Yoshida, Mitsubishi Electric Corporation / Hayato Sano, Mitsubishi Electric Corporation / Yoshiaki Konishi, Mitsubishi Electric Corporation / Naoki Suzuki, Mitsubishi Electric Corporation

F3C.3

Enabling Technology for 9.5-dB SNR Enhancement Utilizing Four-Wave Mixing Between a Conjugate Pair of Angle Modulation for Analog Radio-Over-Fiber Links

Presenter: Shota Ishimura , *KDDI Research, Inc.*

We demonstrate a new application of four-wave mixing which enhances the SNR of angle-modulated RoF signals by 9.5 dB. We experimentally confirmed that the method produced an 8.8-dB enhancement and demonstrated a 400-MHz 1024-QAM transmission.

Authors:Shota Ishimura, KDDI Research, Inc. / Hidenori Takahashi, KDDI Research, Inc. / Takehiro Tsuritani, KDDI Research, Inc. / Masatoshi Suzuki, KDDI Research, Inc.

F3C.4

Transparent Fiber–Radio–Fiber Bridge at 101 GHz Using Optical Modulator and Direct Photonic Down-Conversion

Presenter: Pham Tien Dat , *NICT Network Research Institute*

We demonstrate the first fiber–radio–fiber system in beyond 90 GHz using low loss optical modulator and direct photonic down-conversion. We successfully transmitted 32-/64-QAM OFDM and single-carrier signal with a record line rate of 71.4 Gb/s and net data rate of 53.7 Gb/s.

Authors:Pham Tien Dat, NICT Network Research Institute / Yuya Yamaguchi, NICT Network Research Institute / Keizo Inagaki, NICT Network Research Institute / Masayuki Motoya, Sumitomo Osaka Cement Co., Ltd., / Satoshi Oikawa, Sumitomo Osaka Cement Co., Ltd., / Junichiro Ichikawa, Sumitomo Osaka Cement Co., Ltd., / Atsushi Kanno, NICT Network Research Institute / Naokatsu Yamamoto, NICT Network Research Institute / Tetsuya Kawanishi, Waseda University

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F3C.5

Transmission of 200-GBaud PDM Probabilistically Shaped 64-QAM Signals Modulated via a 100-GHz Thin-Film $LiNbO_3$ I/Q Modulator

Presenter: Xi Chen , *Nokia Bell Labs*

We demonstrate 102-GHz DBI-DAC and 100-GHz I/Q modulator enabled PDM 200-GBaud probabilistically shaped 64-QAM signal carrying up to 7.92 information bits/symbol/2-polarization. A net data rate of 1.58 Tb/s is achieved on a single wavelength.

Authors:Xi Chen, Nokia Bell Labs / Gregory Raybon, Nokia Bell Labs / Di Che, Nokia Bell Labs / Junho Cho, Nokia Bell Labs / kw kim, Nokia Bell Labs

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F3C.6

An Error-Free 1 Tbps WDM Optical I/O Chiplet AndMulti-Wavelength Multi-Port Laser

Presenter: Mark Wade , *Ayar Labs*

We demonstrate 128 Gbps/port (8-λ×16 Gbps/λ) natively error-free transmis-sion across eight optical ports using a 8-port, 8-λ/port WDM remote laser source and a pairof monolithically integrated CMOS optical I/O chiplets with 4.96-5.56 pJ/bit optical Tx+Rxchiplet energy efficiency.

Authors:Mark Wade, Ayar Labs / Erik Anderson, Ayar Labs / Shahab Ardalan, Ayar Labs / Woorham Bae, Ayar Labs / Behrooz Beheshtian, Ayar Labs / Sidney Buchbinder, Ayar Labs / Ken Chang, Ayar Labs / Paulo Chao, Ayar Labs / Haritha Eachempatti, Ayar Labs / John Frey, Ayar Labs / Eric Jan, Ayar Labs / Austin Katzin, Ayar Labs / Anatol Khilo, Ayar Labs / Derek Kita, Ayar Labs / Uma Krishnamoorthy, Ayar Labs / Chen Li, Ayar Labs / Haiwei Lu, Ayar Labs / Fernando Luna, Ayar Labs / Christopher Madden, Ayar Labs / Lynne Okada, Ayar Labs / Mukundrai Patel, Ayar Labs / Chandarasekaran Ramamurthy, Ayar Labs / Manan Raval, Ayar Labs / Radek Roucka, Ayar Labs / Kit Robberson, Ayar Labs / Michael Rust, Ayar Labs / Derek Van Orden, Ayar Labs / Ron Zeng, Ayar Labs / Mason Zhang, Ayar Labs / Vladimir Stojanovic, Ayar Labs / Forrest Sedgwick, Ayar Labs / Roy Meade, Ayar Labs / Norman Chan, Ayar Labs / John Fini, Ayar Labs / Byungchae Kim, Ayar Labs / Songtao Liu, Ayar Labs / Chong Zhang, Ayar Labs / Daniel Jeong, Ayar Labs / Pavan Bhargava, Ayar Labs / Matthew Sysak, Ayar Labs / Chen Sun, Ayar Labs

10:30 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

F4A

Free-space Beam Steering Devices

Presider: Glenn Bartolini

F4A.1

Use of Commercially Available Passive Fiber Optic Components in Emerging Space Laser Communications Applications: Optimizing Performance, Cost, and Reliability

Invited

Presenter: Neal Spellmeyer , *MIT Lincoln Laboratory*

This paper summarizes recent work in developing space laser communications hardware at MIT Lincoln Laboratory, describing how state-of-the-art fiber optic components provide performance and reliability in emerging lasercom system designs

Authors:Neal Spellmeyer, MIT Lincoln Laboratory

F4A.2

Large-Scale Silicon Photonics Focal Plane Switch Array for Optical Beam Steering

Presenter: Xiaosheng Zhang , *University of California, Berkeley*

We report on 128×128-element two-dimensional silicon photonics focal plane switch arrays with microelectromechanical-system optical switches for random-access optical beam steering. A 70°×70° field-of-view and sub-MHz steering speed are experimentally demonstrated.

Authors:Xiaosheng Zhang, University of California, Berkeley / Kyungmok Kwon, University of California, Berkeley / Johannes Henriksson, University of California, Berkeley / Jianheng Luo, University of California, Berkeley / Ming Wu, University of California, Berkeley

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F4A.3

8×8 Programmable Multi-Beam Pattern Projection Based on Multicast Silicon Photonic MEMS Switches

Presenter: Dong Uk Kim , *DGIST*

We present an arbitrary 8×8 beam pattern projection system based on a programmable grating coupler array with a Fourier lens. The static power consumption and the reconfiguration time are below 1μW and 10μs, respectively.

Authors:Dong Uk Kim, DGIST / Myung S. Hong, DGIST / Do Y. Kim, DGIST / Young J. Park, DGIST / Alain Y. Takabayashi, EPFL / Youngjae Jeong, KAIST / Jongwoo Park, KAIST / Seungjun Han, KAIST / Niels Quack, EPFL / Kyoungsik Yu, KAIST / Sangyoon Han, DGIST

F4A.4

Impact of Aperture Size on Beam Evolution of Optical Phased Arrays

Presenter: Weihan Xu , *Shanghai Jiao Tong University (SJTU)*

We investigate the beam evolution of optical phased arrays. The model is validated with a 1-cm-long grating antenna and applied to both large-scale arrays and long antennas for its impact.

Authors:Weihan Xu, Shanghai Jiao Tong University (SJTU) / Chuxin Liu, Shanghai Jiao Tong University (SJTU) / Yuyao Guo, Shanghai Jiao Tong University (SJTU) / Xinhang Li, Shanghai Jiao Tong University (SJTU) / Liangjun Lu, Shanghai Jiao Tong University (SJTU) / Jianping Chen, Shanghai Jiao Tong University (SJTU) / Linjie Zhou, Shanghai Jiao Tong University (SJTU)

F4A.5

Orbital Angular Momentum Mode Multiplexing and Data Transmission Using a Silicon Photonic Integrated MUX

Presenter: Yaoxin Liu , *Technical University of Denmark*

We present a wavelength-independent orbital angular momentum mode-multiplexing chip-design and characterize a newly fabricated chip. We use the chip to simultaneously transmit three OAM modes, each carrying 10-Gbit/s OOK data, over an 800-m ring-core fiber.

Authors:Yaoxin Liu, Technical University of Denmark / Lars Rishøj, Technical University of Denmark / Yunhong Ding, Technical University of Denmark / Quentin Saudan, Technical University of Denmark / Leif Oxenløwe, Technical University of Denmark / Toshio Morioka, Technical University of Denmark

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F4A.6

Large-Scale Programmable Integrated Photonics

Invited

Presenter: Oded Raz , *Technische Universiteit Eindhoven*

A comparison of scaling trends between CMOS and photonic integrated circuits (PIC) shows a need for programmable integrated photonics. Looking beyond current technologies we offer a perspective of nonvolatile and programmable photonic platforms as a route to large scale integration (LSI) photonics

Authors:Oded Raz, Technische Universiteit Eindhoven / Ripalta Stabile, Technische Universiteit Eindhoven / Jimmy Melskens, Eindhoven University of Technology / Franscesco Pagliano, Eindhoven University of Technology / Li Chenhui, Technische Universiteit Eindhoven / Christian Sproncken, Eindhoven University of Technology / Berta Gumi-Audenis, Eindhoven University of Technology / Emilija Lazdanaite, Technische Universiteit Eindhoven / Wilhelmus Kessels, Eindhoven University of Technology / Ilja Voets, Eindhoven University of Technology / Mahir Mohammed, Technische Universiteit Eindhoven

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F4B

Silicon Photonics and Emerging Applications

Presider: Matthew Sysak

F4B.1

Photonic Crystal Modulator in a CMOS Foundry Platform

Presenter: Kenaish Al Qubaisi , *Boston University*

We report the first photonic crystal microcavity modulator realized in a foundry CMOS photonics platform. Bandwidth of 2.8 GHz and 5 Gbps data rate demonstrated utilizing an interdigitated p-n junction in a WDM compatible structure.

Authors:Kenaish Al Qubaisi, Boston University / Deniz Onural, Boston University / Hayk Gevorgyan, Boston University / Milos Popovic, Boston University

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F4B.2

Optical Modulator Based on Transition-Metal Dichalcogenides (TMDs)

Invited

Presenter: Michal Lipson , *Columbia University*

We show that semiconductor monolayers exhibit strong electro-refractive properties at transparency wavelengths, with their |Δn/Δk| response outperforming that of graphene and conventional bulk materials such as silicon, rendering them ideal for large-scale photonic applications.

Authors:Michal Lipson, Columbia University

F4B.3

Silicon Photonics for 2-2.5um Wavelengths

Tutorial

Presenter: Goran Mashanovich , *University of Southampton*

Motivation for developing photonics devices and circuits for the 2-2.5um wavelength range will be given. Various types of passive and active silicon- and germanium-based devices and circuits for this wavelength range will be presented.

Authors:Goran Mashanovich, University of Southampton

F4C

Hollow-core Fibers

Presider: Eric Rodrigue Numkam Fokoua

F4C.1

Opportunities and Challenges for Long-Distance Transmission in Hollow-Core Fibres

Invited

Presenter: Pierluigi Poggiolini , *Politecnico di Torino*

Recently NANF fiber prototypes have shown a steady decrease in loss. Theory predicts they could eventually outperform conventional fibers, in both loss and optical bandwidth. We investigate their potential impact on long-haul optical communication systems.

Authors:Pierluigi Poggiolini, Politecnico di Torino / Francesco Poletti, University of Southampton

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F4C.2

First Demonstration of 400ZR DWDM Transmission Through Field Deployable Hollow-Core-Fibre Cable

Presenter: Md Asif Iqbal , *British Telecommunication*

We report characterisation of ISRS, Kerr-nonlinearity and the first demonstration of error-free DWDM transmission with 38×400G signals using commercial 400ZR QSFP-DD modules through a field deployable 10.25km hollow-core NANF cable with <1.2dB/km loss from 1525-1625nm.

Authors:Md Asif Iqbal, British Telecommunication / Paul Wright, British Telecommunication / Neil Parkin, British Telecommunication / Marcelo Alonso, Lumenisity Limited / Seyed Reza Sandoghchi, Lumenisity Limited / Mike Fake, Lumenisity Limited / Andrew Lord, British Telecommunication

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F4C.3

Low Latency Transmission Over 400 m Hollow-Core-Fiber Cable at 100G PAM-4 per Wavelength

Presenter: Jose Castro , *Panduit Corp*

We present experiments for attenuation, dispersion, and latency characterization of commercially available Hollow Core Fiber cable. We investigate the spectral windows for reliable transmission of 100 Gbps per wavelength using intensity modulation schemes

Authors:Jose Castro, Panduit Corp / Bulent Kose, Panduit Corp / Rick Pimpinella, Panduit Corp / Paul Huang, Panduit Corp / Brett Lane, Panduit Corp / Gabriel Puc, OFS Laboratories / Tristan Kremp, OFS Laboratories / Kyle Dube, OFS Laboratories / Mohandtahar Irid, OFS Laboratories / Brian Mangan, OFS Laboratories

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F4C.4

Design Rules for Multi-Mode Anti-Resonant Hollow-Core Fibres

Presenter: William Shere , *Optoelectronics Research Centre*

Hollow-core fibres typically guide a single low-loss, degenerate spatial mode. Here we present techniques to design HCFs guiding multiple modes with low loss that could be employed in short-haul datacoms or in power delivery.

Authors:William Shere, Optoelectronics Research Centre / Gregory Jasion, Optoelectronics Research Centre / Eric Rodrigue Numkam Fokoua, Optoelectronics Research Centre / Francesco Poletti, Optoelectronics Research Centre

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F4C.5

Low Bending Loss Single-Mode Hollow-Core Anti-Resonant Fiber With Multi-Size Tubes

Presenter: shuai gu , *Beijing Jiaotong University*

An anti-resonant hollow-core fiber with multi-size tubes is successfully fabricated. The fiber is proved to be a robustly single-mode operation with a low bending loss of 0.37dB/m (@1.65μm) under a tight bending radius of 3.5cm.

Authors:shuai gu, Beijing Jiaotong University / XIN WANG, Beijing Jiaotong University / SHIBO YAN, Beijing Jiaotong University / HAOQIANG JIA, Beijing Jiaotong University / SHUQIN LOU, Beijing Jiaotong University / PU WANG, Beijing University of Technology

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F4C.6

Hollow-Core Fiber Characterization With Correlation-Optical Time Domain Reflectometry

Presenter: Florian Azendorf , *ADVA*

Using a Correlation-OTDR, we characterized the temperature-induced group delay variations of two nested antiresonant nodeless hollow core fibers. The temperature sensitivity of both is substantially less than for SSMF with some dependency on coating type.

Authors:Florian Azendorf, ADVA / Bernhard Schmauss, Friedrich Alexander Universität / Eric Rodrigue Numkam Fokoua, University of Southampton / Bo Shi, University of Southampton / Radan Slavik, University of Southampton / Michael Eiselt, ADVA

F4D

DSP for Coherent Transceivers

Presider: Ivan Djordjevic

F4D.1

Quantifying the Gain of Entropy-Loaded Digital Multicarrier for Beyond 100 Gbaud Transmission Systems

Presenter: Trung-Hien Nguyen , *Huawei Technologies France, Paris Research Center*

We investigate the benefit of entropy-loading for digital multicarrier systems operating under colored noise conditions induced by transceiver impairments. We demonstrate up to 0.35 dB Q^2-factor gain for 1 Tb/s capacity with 8-subcarrier 125 GBd PCS-256-QAM.

Authors:Trung-Hien Nguyen, Huawei Technologies France, Paris Research Center / Abel Lorences-Riesgo, Huawei Technologies France, Paris Research Center / Sami Mumtaz, Huawei Technologies France, Paris Research Center / Yu Zhao, Huawei Technologies France, Paris Research Center / Iosif Demirtzioglou, Huawei Technologies France, Paris Research Center / Ivan Fernandez de Jauregui Ruiz, Huawei Technologies France, Paris Research Center / Marti Sales Llopis, Huawei Technologies France, Paris Research Center / Yann Frignac, Huawei Technologies France, Paris Research Center / Gabriel Charlet, Huawei Technologies France, Paris Research Center / Stefanos Dris, Huawei Technologies France, Paris Research Center

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F4D.2

AI-Based Cooperative Optimization of Pre- and Post-Compensation Filters for Coherent Transceivers With Limited Bandwidth and ENOB

Presenter: Marco Fernandes , *Instituto de Telecomunicações de Aveiro*

Using a novel frequency-resolved pre- and post-compensation optimization technique, we show how AI-based optimization can boost the system performance resulting in gains >3 dB over typical pre-emphasis techniques.

Authors:Marco Fernandes, Instituto de Telecomunicações de Aveiro / Bruno Brandão, Instituto de Telecomunicações de Aveiro / Adriano Messias, Idea! Electronic Systems / Tomaz Vilela, Idea! Electronic Systems / Daniel Formiga, Idea! Electronic Systems / Jacklyn Reis, Idea! Electronic Systems / Paulo Monteiro, Instituto de Telecomunicações de Aveiro / Fernando Guiomar, Instituto de Telecomunicações de Aveiro

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F4D.3

Adaptive Pattern-Dependent Equalization for Coherent Optical Fiber Communication Systems

Invited

Presenter: Yi Cai , *Soochow University*

We propose a pattern-dependent equalization scheme facilitating sequence detection in systems with pattern-dependent impairment(s). We experimentally demonstrate effective detection of a 60-GBd QPSK signal with a constrained transmitter bandwidth down to 7.5 GHz.

Authors:Yi Cai, Soochow University / Hungchang Chien, ZTE TX Inc / Meng Xiang, Guangdong University of Technology / Zihe Hu, ZTE TX Inc / Mingyi Gao, Soochow University

F4D.4

Squeezing Out the Achievable Information Rate From Coherent QAM Systems Through Amplitude Modulation of CPE-Pilots

Presenter: Fernando Guiomar , *Instituto De Telecomunicacoes*

We propose to perform amplitude modulation over DSP pilots commonly employed for carrier-phase estimation, utilizing the extra information rate to carry additional FEC overhead. For moderate pilot overheads of 3-6\%, we demonstrate SNR gains in the range of 0.6-1.7\,dB.

Authors:Fernando Guiomar, Instituto De Telecomunicacoes / Beatriz Manata de Oliveira, Instituto De Telecomunicacoes / Manuel Neves, Instituto De Telecomunicacoes / Marco Fernandes, Instituto De Telecomunicacoes / Paulo Monteiro, Instituto De Telecomunicacoes

F4D.5

Evaluation of an Autonomous Digital Pre-Distortion Scheme for Optical Multiband Systems

Presenter: Matheus Sena , *Fraunhofer HHI*

We demonstrate a DSP scheme that autonomously adapts the design of Volterra and memory polynomial digital pre-distortion filters in S+C+L-band transmission. We validate it with a DP-32QAM signal at 64 GBd over 40-km of SSMF.

Authors:Matheus Sena, Fraunhofer HHI / Robert Emmerich, Fraunhofer HHI / Behnam Shariati, Fraunhofer HHI / Johannes Fischer, Fraunhofer HHI / Ronald Freund, Fraunhofer HHI

F4D.6

End-to-end Autoencoder for Superchannel Transceivers With Hardware Impairment

Presenter: Jinxiang Song , *Chalmers University of Technology*

We propose an end-to-end learning-based approach for superchannel systems impaired by non-ideal hardware component. Our system achieves up to 60% SER reduction and up to 50% guard band reduction compared with the considered baseline scheme.

Authors:Jinxiang Song, Chalmers University of Technology / Christian Häger, Chalmers University of Technology / Jochen Schröder, Chalmers University of Technology / Alexandre Graell i Amat, Chalmers University of Technology / Henk Wymeersch, Chalmers University of Technology

F4D.7

Enabling S-C-L-Band Systems With Standard C-Band Modulator and Coherent Receiver Using Nonlinear Predistortin

Presenter: Robert Emmerich , *Fraunhofer Heinrich Hertz Institute*

We experimentally demonstrate S-band reception of 64-GBd PDM-64/32-QAM using standard C-band components. Operation below SD-FEC is enabled by nonlinear transmitter predistortion based on coherent system identification supporting up to 150 nm bandwidth in the S-C-L-band.

Authors:Robert Emmerich, Fraunhofer Heinrich Hertz Institute / Matheus Sena, Fraunhofer Heinrich Hertz Institute / Robert Elschner, Fraunhofer Heinrich Hertz Institute / Carsten Schmidt-Langhorst, Fraunhofer Heinrich Hertz Institute / Isaac Sackey, Fraunhofer Heinrich Hertz Institute / Colja Schubert, Fraunhofer Heinrich Hertz Institute / Ronald Freund, Fraunhofer Heinrich Hertz Institute

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F4E

Quantum Communications

Presider: Rui Lin

F4E.1

Demonstration of Probabilistic Constellation Shaping for Continuous Variable Quantum Key Distribution

Presenter: François Roumestan , *Nokia Bell Labs France*

We demonstrate, for the first time to our knowledge, continuous-variable quantum key distribution using probabilistically-shaped 1024-QAM and true local oscillator, achieving 38.3Mb/s secret key rate over 9.5km, averaged over the transmission time of 100 blocks.

Authors:François Roumestan, Nokia Bell Labs France / Amirhossein Ghazisaeidi, Nokia Bell Labs France / Jeremie Renaudier, Nokia Bell Labs France / Patrick Brindel, Nokia Bell Labs France / Eleni Diamanti, Sorbonne Université / Philippe Grangier, Université Paris-Saclay

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F4E.2

CV-QKD System Using a Commercial Coherent Transceiver Module

Presenter: Max Rückmann , *Helmut Schmidt Univ, Univ of FAF Hamburg*

We demonstrate a CV-QKD system that achieves key rates of 2.5 Mbit/s over 20 km using a cost-efficient transmitter based on a commercially available integrated coherent transceiver module.

Authors:Max Rückmann, Helmut Schmidt Univ, Univ of FAF Hamburg / Christian G. Schaeffer, Helmut Schmidt Univ, Univ of FAF Hamburg

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F4E.3

A Resource-Effective QKD Field-Trial in Padua With the IPOGNAC Encoder

Presenter: Marco Avesani , *Universita degli Studi di Padova*

We describe a novel low-error and calibration-free polarization encoder for Quantum Key Distribution, called iPOGNAC. The device, together with the Qubit4Sync synchronization, has been used to realize a resource-effective QKD field-trial in Padua, Italy.

Authors:Marco Avesani, Universita degli Studi di Padova / Luca Calderaro, Universita degli Studi di Padova / Giulio Foletto, Universita degli Studi di Padova / Costantino Agnesi, Universita degli Studi di Padova / Francesco Picciariello, Universita degli Studi di Padova / Francesco Santagiustina, Universita degli Studi di Padova / Alessia Scriminich, Universita degli Studi di Padova / Andrea Stanco, Universita degli Studi di Padova / Francesco Vedovato, Universita degli Studi di Padova / Mujtaba Zahidy, Universita degli Studi di Padova / Giuseppe Vallone, Universita degli Studi di Padova / Paolo Villoresi, Universita degli Studi di Padova

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F4E.4

Fully Connected Entanglement-Based Quantum Communication Network Without Trusted Node

Presenter: Xu Liu , *Tsinghua University*

We proposed a fully connected quantum communication network architecture based on multi-user entanglement distribution by space multiplexing and wavelength multiplexing technologies. A fully connected QKD network with 40 users was demonstrated experimentally.

Authors:Xu Liu, Tsinghua University / Rong Xue, Tsinghua University / Yidong Huang, Tsinghua University / Wei Zhang, Tsinghua University

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F4E.5

Analysis of the Impact of Radiation-Induced Optical Transients on Deep-Space Optical Communications Systems Using PPM

Presenter: George Tzintzarov , *Georgia Institute of Technology*

An analysis on the effects of radiation-induced optical transients in a communications link using PPM is presented. The probability of symbol errors is shown to increase due to ionizing radiation-induced depletion of the optical signal.

Authors:George Tzintzarov, Georgia Institute of Technology / Jeffrey Teng, Georgia Institute of Technology / Adrian Ildefonso, The U.S. Naval Research Laboratory / John Cressler, Georgia Institute of Technology

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F4E.6

Minimizing Spontaneous Raman Scattering Noise for Quantum Key Distribution in WDM Networks

Presenter: Rui Lin , *Chalmers University of Technology*

We analytically model the SRS impact on QKD when sharing C-band for quantum and classical communications in WDM networks, the optimal wavelength allocation can increase more than 26% achievable transmission distance for the quantum signals.

Authors:Rui Lin, Chalmers University of Technology / Jiajia Chen, Chalmers University of Technology

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F4E.7

Quantum RNG Integration in an NG-PON2 Transceiver

Presenter: Nemanja Vokic , *AIT Austrian Institute of Technology*

We propose a minimally invasive optical overlay for time-interleaved QRNG operation in NG-PON2 transceivers. We experimentally demonstrate that random numbers can be generated at a 0.5 Gb/s rate and validate the randomness through statistical tests.

Authors:Nemanja Vokic, AIT Austrian Institute of Technology / Dinka Milovancev, AIT Austrian Institute of Technology / Christoph Pacher, AIT Austrian Institute of Technology / Martin Achleitner, AIT Austrian Institute of Technology / Hannes Hübel, AIT Austrian Institute of Technology / Bernhard Schrenk, AIT Austrian Institute of Technology

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F4F

Fiber Wireless Subsystems

Presider: Daniel Blumenthal

F4F.1

Thz Integrated Electronic and Hybrid Electronic-Photonic Systems

Tutorial

Presenter: Kaushik Sengupta , *Princeton University*

In this talk, I will highlight electronics and photonics-inspired approaches to miniaturize complex Terahertz systems into fully integrated silicon-based chips enabling programmable THz metasurfaces, programmable THz sensing and physically secure links for sensing and communication applications.

Authors:Kaushik Sengupta, Princeton University

F4F.2

Experimental Analysis of Fourier Transform Based Blind Frequency Offset Estimation for PS-QAM in W-Band Fiber-Millimeter Wave Integrated System

Presenter: Shuang Yao , *Georgia Institute of Technology*

Blind FOE for PS-QAM is experimentally analyzed in fiber-mmWave integrated system. QS-FOE can relax the requirements on FFT size, shaping factor and laser linewidth of the FFT-FOE by improving PMNR by more than 10 dB.

Authors:Shuang Yao, Georgia Institute of Technology / Chin-Wei Hsu, Georgia Institute of Technology / Rui Zhang, Georgia Institute of Technology / Shuyi Shen, Georgia Institute of Technology / Qi Zhou, Georgia Institute of Technology / Shang-Jen Su, Georgia Institute of Technology / Yahya Alfadhli, Georgia Institute of Technology / John R. Barry, Georgia Institute of Technology / Gee-Kung Chang, Georgia Institute of Technology

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F4F.3

Integrated Dual-DFB Laser Chip-Based PAM-4 Photonic-Wireless Transmission in W-Band

Presenter: Shi Jia , *DTU Fotonik*

We experimentally demonstrate lens-free photonic-wireless transmission in the W-band using a monolithically integrated dual-DFB laser, which is injection-locked by a frequency comb to generate two 90-GHz-spacing phase-stabilized carriers and modulated with a 40-Gbit/s PAM-4 signal.

Authors:Shi Jia, DTU Fotonik / Mu-Chieh Lo, Universidad Carlos III de Madrid / Deming Kong, DTU Fotonik / Robinson Guzman, Universidad Carlos III de Madrid / Longsheng Li, DTU Fotonik / Leif Oxenløwe, DTU Fotonik / Guillermo Carpintero, Universidad Carlos III de Madrid / Hao Hu, DTU Fotonik

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F4F.4

Photonic Integrated Circuits for Terahertz Communication: the Hybrid Integrated Microwave Photonic Approach

Invited

Presenter: Guillermo Carpintero , *Universidad Carlos III de Madrid*

Optical heterodyne signal generation is the most flexible photonic microwave generation technique. Photonic integrated solutions have been shown monolithically on InP and more recently on silicon. We present novel hybrid integration technology on silicon nitride (with high-Q resonators) and polymer (with low permittivity material).

Authors:Guillermo Carpintero, Universidad Carlos III de Madrid / LUIS GONZALEZ-GUERRERO, Universidad Carlos III de Madrid / Robinson Guzman, Universidad Carlos III de Madrid / Muhsin Ali, Universidad Carlos III de Madrid / David de Felipe, Fraunhofer Heinrich Hertz Institute / Tianwen Qian, Fraunhofer Heinrich Hertz Institute / Norbert Keil, Fraunhofer Heinrich Hertz Institute / Robert Grootjans, LioniX International BV / Chris Roeloffzen, LioniX International BV

F4G

Next Generation Field Trials and Standardization

Presider: Georg Mohs

F4G.1

High Baud Rate Modulation: Applications for Next-Generation Backbone Networks

Invited

Presenter: Jeffrey Rahn , *Facebook Inc.*

95 GBaud transponders, equipped with probabilistic shaping and advanced FEC, improve backbone networks by reducing power and increasing spectral efficiency. We review network expectations and observations for this class of transponder.

Authors:Jeffrey Rahn, Facebook Inc. / Elizabeth Rivera Hartling, Facebook Inc. / Stephen Grubb, Facebook Inc. / Steve Armstrong, Facebook Inc. / Vishal Gadiya, Facebook Inc. / Matthew Mitchell, Facebook Inc.

F4G.2

Trans-Atlantic Real-Time Field Trial Using Super-Gaussian Constellation-Shaping to Enable 30Tb/s+ Capacity

Presenter: Marc Stephens , *Infinera*

A record real-time capacity capability of 30.01Tb/s is demonstrated across a 6644km trans-Atlantic subsea link using super-Gaussian shaped PS-64QAM. We additionally report the first 700Gb/s payload transmission at 100.4GBaud across the same route.

Authors:Marc Stephens, Infinera / Pierre Mertz, Infinera / Stephen Grubb, Facebook / Gary Shartle, Infinera / Ales Kumpera, Infinera / Jim O'Connor, Infinera / Robert Maher, Infinera / Mohammad Chitgarha, Infinera / Clayton Doggart, Infinera / Sandy Thomson, Infinera / Sumudu Edirisinghe, Infinera / Alexandre Afonso, Infinera / Michael Elam, Infinera / Konstantin Gelov, Smartcom / Buen Boyanov, Smartcom / Vince Dominic, Infinera / Steve Sanders, Infinera / Parthiban Kandappan, Infinera

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F4G.3

Unrepeatered Transmission of Single-Carrier 800Gb/s Over 404km With Commercial Transceiver and Enhanced ROPA System

Presenter: Xu Jian , *ACCELINK*

This paper demonstrates a record unrepeatered transmission of single-carrier 800Gb/s over 404.39km (63.49dB) with a single fiber configuration, using sub-carrier Frequency-Division Multiplexing, optimized high-order Raman pump, forward and backward ROPAs, and ultra-low loss & large effective area fiber.

Authors:Xu Jian, ACCELINK / Jianjun WU, ACCELINK

F4G.4

(Withdrawn) Standardization for Coherent System: Methology and Specification

Invited

Presenter: Tad Hofmeister , *Google LLC*

Abstract not available.

Authors:Tad Hofmeister, Google LLC

F4G.5

20.8 Tb/s Transmission Over 1200 km Using G654E Fibers, Hybrid Amplification and 400 Gb/s CFP2-DCO Interfaces

Presenter: Bruno Lavigne , *Alcatel Submarine Networks*

By using a 400 Gb/s 64Gbaud CFP2-DCO interface, we show error free transmission on fifty-two 75 GHz-spaced spectral positions of a fully loaded 4800 GHz-wide WDM comb over 1200km of G654E fiber with hybrid amplification.

Authors:Bruno Lavigne, Alcatel Submarine Networks / Mael Le Monnier, Alcatel Submarine Networks / Thierry Zami, Alcatel Submarine Networks / Dirk Bode, Nokia / Giuseppe Azzini, Nokia / Roberto Peruta, Nokia / Luca Suberini, Nokia / Sergio Jovane, Nokia / oriol bertran-pardo, Nokia / Amirhossein Ghazisaeidi, Nokia Bell-Labs

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F4H

Emerging Network Architectures for 5G and Beyond

Presider: Paolo Monti

F4H.1

Toward 6G: a New Era of Convergence

Invited

Presenter: Martin Maier , *Institut National de la Recherche Sci.*

This paper highlights some of the 6G driving trends and reports on early findings, starting from an optical fiber networks perspective all the way to human-avatar/robot collectives and extended reality in the 6G post-smartphone era.

Authors:Martin Maier, Institut National de la Recherche Sci.

F4H.2

A Latency-Aware Real-Time Video Surveillance Demo: Network Slicing for Improving Public Safety

Presenter: Behnam Shariati , *Fraunhofer Inst Nachricht Henrich-Hertz*

We report the automated deployment of 5G services across a latency-aware, semi-disaggregated, and virtualized metro network. We summarize the key findings in a detailed analysis of end-to-end latency, service setup time, and soft-failure detection time.

Authors:Behnam Shariati, Fraunhofer Inst Nachricht Henrich-Hertz / José Juan Pedreño Manresa, ADVA / Annika Dochhan, ADVA / Abubakar Siddique Muqaddas, University of Bristol / Ramon Casellas, CTTC/CERCA / Oscar Gonzalez de dios, Telefonica / Lourdes Luque Canto, Telefonica / Bodo Lent, Qognify GmbH / Jorge López de Vergara Méndez, Naudit HPCN / Sergio López-Buedo, Naudit HPCN / FRANCISCO JAVIER MORENO MURO, Universidad Politécnica de Cartagena / PABLO PAVÓN, Universidad Politécnica de Cartagena / Luis Velasco, Universitat Politecnica de Catalunya / Sai Patri, ADVA / Alessio Giorgetti, CNIT / Filippo Cugini, CNIT / Andrea Sgambelluri, CNIT / Reza Nejabati, University of Bristol / Dimitra Simeonidou, University of Bristol / Ralf-Peter Braun, Deutsche Telekom / Achim Autenrieth, ADVA / Jörg-Peter Elbers, ADVA / Johannes Fischer, Fraunhofer Inst Nachricht Henrich-Hertz / Ronald Freund, Fraunhofer Inst Nachricht Henrich-Hertz

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F4H.3

Capturing Value From Latency Control in Time-Slotted Optical Communications: a Techno-Economic Assessment

Presenter: Mijail Szczerban , *Nokia Bell Labs*

We assess the value of deterministic latency and propose pricing models to monetize this network feature. We show how to achieve a threefold monetary return increase in certain network configurations and time-sensitive application environments.

Authors:Mijail Szczerban, Nokia Bell Labs / Sebastien Bigo, Nokia Bell Labs / Nihel Benzaoui, Nokia Bell Labs

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F4H.4

Optical Continuum Architectures for Beyond 5G Domainless Network Operation

Invited

Presenter: Oscar Gonzalez de dios , *Telefonica*

Abstract not available.

Authors:Oscar Gonzalez de dios, Telefonica

F4H.5

Autonomous SDN-Based Global Concurrent Restoration for High-Capacity Optical Metro Networks

Presenter: Ricardo Martínez , *Centre Tecn. Telecom. Catalunya (CTTC)*

The full integration of an OAM function with a SDN controller to support autonomic networking capabilities within optical metro networks is presented. A devised Global Concurrent RSA algorithm to maximize connection restorability is experimentally evaluated.

Authors:Ricardo Martínez, Centre Tecn. Telecom. Catalunya (CTTC) / Ramon Casellas, Centre Tecn. Telecom. Catalunya (CTTC) / Michela Svaluto Moreolo, Centre Tecn. Telecom. Catalunya (CTTC) / Josep Maria Fabrega, Centre Tecn. Telecom. Catalunya (CTTC) / Ricard Vilalta, Centre Tecn. Telecom. Catalunya (CTTC) / Raul Muñoz, Centre Tecn. Telecom. Catalunya (CTTC) / Laia Nadal, Centre Tecn. Telecom. Catalunya (CTTC) / Juan-Pedro Fernández-Palacios, Telefónica I+D / Victor López, Telefónica I+D / David Larrabeiti, Universidad Carlos III / Gabriel Otero, Universidad Carlos III / José Alberto Hernández Gutiérrez, Universidad Carlos III

F4H.6

First Scalable Machine Learning Based Architecture for Cloud-Native Transport SDN Controller

Presenter: Carlos Manso , *CTTC*

We present a cloud-native architecture with a machine learning QoT predictor that enables cognitive functions in transport SDN controllers. We evaluate the QoT predictor training and auto-scaling capabilities in a real WDM/SDM testbed.

Authors:Carlos Manso, CTTC / Noboru Yoshikane, KDDI Research / Ricard Vilalta, CTTC / Raul Muñoz, CTTC / Ramon Casellas, CTTC / Ricardo Martínez, CTTC / Cen Wang, KDDI Research / Filippos Balasis, KDDI Research / Takehiro Tsuritani, KDDI Research / Itsuro Morita, CTTC

F4I

Low Latency Access Networks

Presider: Junwen Zhang

F4I.1

Packet Optical Networks and SDN at the Edge

Invited

Presenter: Marina Thottan , *Nokia Bell Labs*

Abstract not avialable.

Authors:Marina Thottan, Nokia Bell Labs

F4I.2

A Novel low-Latency DBA for Virtualised PON Implemented Through P4 in-Network Processing

Presenter: Diego Rossi Mafioletti , *Trinity College Dublin*

We present a novel dual-DBA allocation, with a fast P4-enabled scheduler to provide low latency upstream grant allocations. We show latency reduction of 37% and 43%, respectively, compared to standard and virtual PONs.

Authors:Diego Rossi Mafioletti, Trinity College Dublin / Frank Slyne, Trinity College Dublin / Robin Giller, Intel Corporation / Michael O'Hanlon, Intel Corporation / Brendan Ryan, Intel Corporation / Marco Ruffini, Trinity College Dublin

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F4I.3

DRL-Based Channel and Latency Aware Scheduling and Resource Allocation for Multi-User Millimeter-Wave RAN

Presenter: Shuyi Shen , *Georgia Institute of Technology*

A DRL-based uplink resource allocation algorithm with channel condition and latency awareness is demonstrated for multi-user RAN. The algorithm is verified experimentally with dynamic RoF-mmWave channels, achieving 19% reward improvement compared to conventional scheduling schemes.

Authors:Shuyi Shen, Georgia Institute of Technology / Ticao Zhang, Auburn University / Shiwen Mao, Auburn University / Gee-Kung Chang, Georgia Institute of Technology

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F4I.4

Strategies for Implementing Edge Services in the 5G/10G Network

Invited

Presenter: Eric Heaton , *Intel Corp.*

This talk will explore possible Edge Service models for operators, the equipment and software infrastructure needed to enable them, and deployment strategies to deliver on specific business or technology goals.

Authors:Eric Heaton, Intel Corp.

F4I.5

Experimental Demonstrations of Concurrent Adaptive Inter-ONU and Upstream Communications in IMDD Hybrid SSB OFDM-DFMA PONs

Presenter: Zhuqiang Zhong , *Bangor University*

Concurrent adaptive inter-ONU and upstream communications are experimentally demonstrated in 25km@101.6Gbit/s IMDD hybrid SSB OFDM-DFMA PONs, offering a promising candidate to meet 5G and beyond networks' requirements in terms of latency, bitrate and connection density.

Authors:Zhuqiang Zhong, Bangor University / Wei Jin, Bangor University / Shan Jiang, Bangor University / Jiaxiang He, Bangor University / Da Chang, Bangor University / Roger Giddings, Bangor University / Yanhua Hong, Bangor University / Maurice O'Sullivan, Ciena Canada, Inc. / Tim Durrant, EFFECT Photonics LTD. / Giordano Mariani, EFFECT Photonics B.V. / Jeremy Trewern, EFFECT Photonics B.V. / Jianming Tang, Bangor University

F4J

Panel: Is Optical Switching Finally Ready for Large-scale Deployment in Datacenters and Advanced Networks?

11:30 - 12:30 Pacific Time (US & Canada) (UTC - 07:00)

SF17

Exhibit Hall Event - Industry Program: AIM Photonics Member Successes and Updates

11:30 - 13:00 Pacific Time (US & Canada) (UTC - 07:00)

MW2

Exhibit Hall Event - Market Watch: The Industrial Internet of Things, Smart Manufacturing and Industry 4.0

SF16

Exhibit Hall Event - Industry Program: 400ZR Deployment and What's Next: An OIF Update

12:30 - 13:00 Pacific Time (US & Canada) (UTC - 07:00)

SpE18

Exhibit Hall Event - OSA Booth, Tech Talk: Optical System innovations in DCI transport networks

12:30 - 13:30 Pacific Time (US & Canada) (UTC - 07:00)

Exhibit Hall Event - Dedicated Exhibit Time - Watch the Analyst Briefing - a daily overview of product announcements and exhibitor news