Join us in the historic and vibrant city of Glasgow for the 49th edition of ECOC.

We will continue ECOC’s tradition of showcasing the latest cutting-edge developments in optical communication, as well as an exciting social programme that will allow delegates to network and share ideas whilst experiencing the best of Scottish culture.

Visit us at stand 525 to find out more about ECOC 2023, or how you can raise your brand’s profile with sponsorship opportunities.

See the latest news about ECOC at ecoc2023.org

Join us next year in Scotland

1 – 5 October 2023 | SEC | Glasgow | UK
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# Programme Overview

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<td>08:00 - 18:00</td>
<td>Registration, Entrance Hall 1</td>
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<tr>
<td>09:00 - 10:30</td>
<td>Mo3A • Role of Optical Network for Split Computing Between Edge and Cloud in Support of Ultra Low Latency Services</td>
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<tr>
<td>10:30 - 11:00</td>
<td>Coffee Break, Foyer 2nd Floor</td>
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<tr>
<td>11:00 - 12:30</td>
<td>Mo4A • Sensing with Workshops on Photonic Startups</td>
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<tr>
<td>12:30 - 14:00</td>
<td>Lunch Break</td>
</tr>
<tr>
<td>14:00 - 15:30</td>
<td>Tu1A • Co-Packaging and Optical Platforms and Sources I</td>
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<tr>
<td>15:30 - 16:00</td>
<td>Coffee Break, Foyer 2nd Floor</td>
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<tr>
<td>16:00 - 17:30</td>
<td>Mo5A • Poster Pitch Session I</td>
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<tr>
<td>17:30 - 19:00</td>
<td>Gala Dinner, MS Rhystätten, Schifflände Basel</td>
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<td>18:00 - 19:00</td>
<td>Welcome Reception, Mootkalle Basel</td>
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<tr>
<td>19:00 - 21:00</td>
<td>Get Together Reception, Foyer 2nd Floor</td>
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<tr>
<td>08:00 - 19:00</td>
<td>Registration, Entrance Hall 1</td>
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<tr>
<td>09:00 - 10:30</td>
<td>Mo1 • Opening Remarks and Joint Plenary Session, San Francisco</td>
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<td>11:00 - 12:30</td>
<td>Mo2 • Joint Plenary Session, San Francisco</td>
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<td>12:30 - 13:30</td>
<td>Lunch Break</td>
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<tr>
<td>13:30 - 15:15</td>
<td>Mo3B • Low Margin Optical Networks</td>
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<tr>
<td>15:15 - 15:45</td>
<td>Mo3C • Optical Access Networks for Mobile Com.</td>
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<td>Mo4B • Edge Cloud and Low Latency</td>
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<td>17:30 - 18:30</td>
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<td>Tu3B • Security</td>
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<td>Tu4B • Symposium: Recent Advances in Submarine Systems</td>
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<td>17:30 - 19:00</td>
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<td>19:30 - 23:00</td>
<td>Tu5 • Poster Session I</td>
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**Monday, 19 September**

**Tuesday, 20 September**
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<tr>
<th>Time</th>
<th>Th1A • Novel Fiber Fabrication Methods</th>
<th>Th1B • Symposium: Free Space Optical Communication for Terrestrial &amp; Space Applications</th>
<th>Th1C • Novel Equalization Techniques</th>
<th>Th1D • SDM Transmission and Monitoring Systems</th>
<th>Th1E • High-speed Transmitter Devices</th>
<th>Th1F • Novel PICs and Applications</th>
<th>Th1G • Quantum Communication</th>
<th>Th1H • Symposium: Prospects for the Usage of Millimeter Wave Bands</th>
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**Colour Legend & Technical Subcommittees**

- SC1: Novel Fibres, Fibre Devices & Amplifiers
- SC2: Photonic Devices & Technologies
- SC3: Photonic Integrated Circuits, Assemblies & Packaging
- SC4: Techniques for Digitally Enhancing Optical Communication
- SC5: Theory of Optical Communications
- SC6: Optical Transmission Systems
- SC7: Core & Metro Networks
- SC8: Access, Indoor & Short-Reach for Data Centres and Mobile Networks
- SC9: Photonics for RF & Free-Space Optics Applications
- SC10: Architecture, Control & Management of Optical Networks
- SC11: Quantum Photonic Devices & Technologies
- SC12: Quantum Integrated Photonics
- CLEO-Q: CLEO/Europe Focus Meeting – Quantum Photons
- CLEO-MS: CLEO/Europe-Middle East Conference – Materials Science
- CLEO-OE: CLEO/Europe Focus Meeting – Optics Engineering
- Plenary, Postdeadline, Poster & Demo
- Plenary, Postdeadline, Poster & Demo
- Plenary, Postdeadline, Poster & Demo
- Plenary, Postdeadline, Poster & Demo
- Plenary, Postdeadline, Poster & Demo

**CLEO-MD: CLEO/Europe Focus Meeting – Novel Materials & Emerging Devices**

**Social Events**

- Closing Ceremony, Singapore
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Dear Friends & Colleagues: Welcome to Basel!

The joint Chairs say “Grüezi” and welcome you to 48th European Conference on Optical Communication in Basel, Switzerland in the heart of Europe.

Basel is Switzerland’s cultural capital and its oldest university city. It offers a beautiful Old Town with historic and scenic landmarks such as the market square or the river Rhine. Get the chance to experience technology, culture, and history all within walking distance from the conference centre.

The European Conference on Optical Communication (ECOC) as one of the leading conferences on optical communication attracts scientists and researchers from across the world. Not only top universities, but also the world’s biggest and most influential companies present their astonishing breakthroughs from materials and devices to systems and networks, and their insightful visions for the future. ECOC is the key meeting place to share knowledge, exchange ideas, foster innovation and start collaborations on a global level. ECOC also features Europe’s largest exhibition in the field, where you get the chance to see the latest products, find new customers or intensify your current relationships.

ECOC has a long tradition with the first meeting being held in 1974, triggered by the breakthrough experimental demonstration of optical fibres with loss below 20 dB/km in 1970 by the Corning team of Donald Keck, Robert Maurer, and Peter Schulz. ECOC took place ever since in yearly conferences, now for the 48th time. In the meantime, more than 5 billion km of fibre (33 times the distance from Earth to Sun) has been deployed. A number that gives testimony to this game changing technology that has paved the way for today’s internet and personal communications. And as the innovation continues, meetings such as the ECOC are needed to report on breakthroughs and novel applications in optics and communications.

ECOC 2022 is featuring five exciting plenary speakers:
- Nobel prize laureate Didier Queiroz on the discovery of exoplanets with optical technology
- Elisabetta Rugi Grond, CEO Thales Alenia Space Switzerland, on “Optical space communications: Challenges and opportunities”
- David F. Welch, CIO & co-founder Infinera on “Scenarios of future innovations in the network”
- Dr Christoph Glingener, CTO ADVA, on optical networking: “Never say never again”
- Dr Mark G. Thompson, CTO PsiQuantum on “Path to a useful quantum computer”

ECOC 2022 offers an extensive technical programme with:
- 15 workshops on industry’s hottest topics
- 12 symposia to give in-depth coverage on latest trends
- 77 Invited presentations delivered by experts in the field
- 11 in-depth tutorials
- 6 short courses
- 68 Technical Sessions with 245 papers
- 2 Poster Sessions with 145 papers
- 4 postdeadline paper sessions with up-to-the-minute research
- CLEO®/Europe Focus Meeting on novel materials, emerging devices, & quantum technology

Selected highlights from the special technical programme at ECOC 2022 are:
- Workshops on PIC technology and co-integration
- Workshop & symposium on quantum communication
- Workshops & symposia on the latest trends: Free space optics, THz photonics, photonic memristors, …
- Short courses on: machine learning, space division multiplexing, forward error correction, modulation formats & receiver concepts, radio-over-fiber technologies
- Rump session on “Analysis and Real Opportunities from the Hyped Big Trends in Photonics” inviting to a vivid controversial discussion

The conference also runs alongside the ECOC Exhibition with over 250 exhibitors. Highlights this year include the live Market Focus presentations, product demonstrations, a job wall, and an industry award ceremony. The event will once again be a meeting place, knowledge centre, and platform to showcase the latest optical technology as innovators, thought leaders and global companies arrive in the city of Basel.

We are delighted to welcome you at ECOC in Basel and hope you are enjoying the technical and social aspects of ECOC!
European Management Committee (EMC)
Peter Andrekson, Chalmers University of Technology, Sweden
Sébastien Bigo, Nokia Bell Labs, France
Antonella Bogoni, Sant’Anna School of Advanced Studies, Italy
Jose Capmany, Polytechnic University of Valencia, Spain
Jörg-Peter Elbers, ADVa Optical Networking SE, Germany
Ronald Freund, Fraunhofer Heinrich Hertz Institute, Germany
Piero Gambini, STMicroelectronics, Italy
Ton Koonen, Eindhoven University of Technology, The Netherlands
Christian Lemminiaux, Chimie ParisTech – PSL, France
Jürg Leuthold, ETH Zurich, Switzerland
Leif Katsuo Oxenløwe, Technical University of Denmark, Denmark
David Richardson, University of Southampton, United Kingdom
Will Stewart, University of Southampton, United Kingdom
Peter Van Daele, IMEC - Ghent University, Belgium

International Advisory Committee (IAC)
Simon Fleming, University of Sydney, Australia
Pat Iannone, Nokia Bell Labs, USA
Jintong Lin, Beijing University of Posts and Telecommunications, China
Toshio Monoka, Technical University of Denmark, Denmark
Clint Schow, University of California Santa Barbara, USA

CLEO®/Europe Focus Meeting Co-Chairs
Giacomo Scalari, ETH Zurich, Switzerland
Anna Fontcuberta i Morral, EPFL, Switzerland
Patrick Maletinsky, University of Basel, Switzerland
Philipp Treutlein, University of Basel, Switzerland

Sub-Committees
SC1 – Novel Fibres, Fibre Devices & Amplifiers
Chair: Camille Brès, EPFL, Switzerland
Marianne Bigot, Pysmian, France
Christian-Alexander Bunge, Leipzig University of Applied Sciences, Germany
Tommy Geisler, OFS, Denmark
Iain McClean, II-VI, UK
Kazunori Mukasa, Furukawa Electric Co. Ltd., Japan

SC3 – Photonic Integrated Circuits, Assemblies & Packaging
Chair: Dan Kuchta, IBM Research, USA
Selina Fanwell, Lumentum, UK
Folkert Horst, IBM Research, Switzerland
Daniel Pérez-Lopez, iPronics, Spain
Mads Lønstrup Nielsen, NVIDIA, Denmark
Nobuhiko Nishiyama, Tokyo Institute of Technology, Japan
Ségolène Olivier, LETI, France
David Plant, McGill University, Canada
Günther Roelkens, Ghent University, Belgium
Hamed Sattari, CSEM, Switzerland
Patty Stabile, Eindhoven University of Technology, Netherlands
Keijiro Suzuki, AIST, Japan
Xin (Scott) Yin, imec - Ghent University, Belgium
Lars Zimmermann, iHP GmbH, Germany

SC4 – Techniques for Digitally Enhancing Optical Communication
Chair: Chigo Onokwuo, Eindhoven University of Technology, Netherlands
Elie Awwad, IMT ParisTech, France
Xi (Vivien) Chen, Nokia Bell Labs, USA

SC2 – Photonic Devices & Technologies
Chair: Jörg Wieland, Tetrasemiconductors, Switzerland
Timo Aalto, VTT, Finland
Yuliya Akulova, Intel, USA
Andreas Beling, University of Virginia, USA
Woo-Young Choi, Yonsei University, Korea
Hélène Debreges, Almae, France
Xuhan Guo, Shanghai Jiao Tong, China
Jon Heffernan, University of Sheffield, UK
Christian Koos, Karlsruhe Institute of Technology, Germany
Dan Marom, Hebrew University, Israel
Shinji Matsuo, NTT, Japan
Lucas Soldano, Poet Technologies, Italy
Mitsuru Takenaka, University of Tokyo, Japan
Jean Teissier, II-VI Laser Enterprise, Switzerland

SC5 – Theory of Optical Communications
Chair: René Essiambre, Nokia Bell Labs, USA
Alex Alvarado, Eindhoven University of Technology, Netherlands
Christian Antonelli, Università dell’Aquila, Italy
Junho Cho, Nokia Bell Labs, USA
Francisco Díaz Otero, Universidad de Vigo, Spain
Helmut Griesser, ADVa Optical Networking GmbH, Germany
Magnus Karlsson, Chalmers University, Sweden
Domenico Marsella, Nokia, Italy
Luiz Anet Neto, IMT Atlantique, France
Maria Sorokina, Aston University, UK
Chongjin Xie, Alibaba, USA
Masato Yoshida, Tohoku University, Japan

SC6 – Optical Transmission Systems
Chair: Fatima Gunning, Tyndall National Institute, Ireland
Lidia Galdino, University College London, UK
Norbert Hanik, Technical University of Munich, Germany
Tomoyuki Kato, Fujitsu, Japan
Hoon Kim, KAIST, Korea
Takayuki Kobayashi, NTT, Japan
Beatriz Ortega, Universitat Politècnica de Valencia, Spain
Jeremie Renaudier, Nokia Bell Labs, France
Jochen Schröder, Chalmers University, Sweden
Paolo Serena, Parma University, Italy
Jaroslav Turkiewicz, Warsaw University of Technology, Poland
Jian Wu, Beijing University of Posts & Telecom, China

SC7 – Core & Metro Networks
Chair: Nicola Calabretta, Eindhoven University of Technology, Netherlands
Dimitrios Apostolopoulos, National Technical University of Athens, Greece
Benedikt Baueuerle, Polariton, Switzerland
Andrea Carena, Politecnico di Torino, Italy
Admela Jukan, Technical University of Braunschweig, Germany  
Patricia Layec, Nokia Bell Labs, France  
Ci Wen Charles Lim, NUS, Singapore  
Oskars Ozolins, RISE, Sweden  
Nick Parsons, Polatis, UK  
Bernhard Schrenk, Austrian Institute of Technology, Austria  
Alexandros Stavdas, University of Peloponess, Greece  
Takehiro Tsuritani, KDDI Research Inc., Japan  
Carmen Vazquez, Universidad Carlos III de Madrid, Spain  
Tianjian Zuo, Huawei, China  

SC8 – Access, Indoor & Short-Reach for Data Centres and Mobile Networks  
Chair: Francesca Parmigiani, Microsoft, UK  
Fabio Bottoni, Cisco, Italy  
Zhangyuan Chen, Peking University, China  
Jochen Maes, Nokia Bell Labs, Belgium  
Stephan Pachnicke, Christian-Albrecht University of Kiel, Germany  
Paola Parolari, Politecnico di Milano, Italy  
Nikos Pleros, Aristotle University of Thessaloniki, Greece  
Fabienne Salou, Orange, France  
Michela Svaluto Moreolo, CTC, Spain  
Karl Tran, Genexis, Netherlands  
Tomoko Yoshida, NTT, Japan  
Satoshi Yoshima, Mitsubishi Electric, Japan  

SC9 – Photonics for RF & Free-Space Optics Applications  
Chair: Reto Muff, Thales Alenia Space, Switzerland  
Liam Barry, Dublin City University, Ireland  
Matt Brandt-Pearce, University of Virginia, USA  
Zicheng Cao, Eindhoven University of Technology, Netherlands  
Guillemo Carpintero, Universidad Carlos III de Madrid, Spain  
Fabio Cavaliere, Ericsson, Italy  
Chi Wai Chow, National Yang Ming Chiao Tung University, Taiwan  
Hwanseok Chung, ETRI, Korea  
Mathilde Gay, Institut Foton, France  
Harald Haas, University of Strathclyde, UK  
Shota Ishimura, KDDI Research Inc., Japan  
Peter Osseur, imec - Ghent University, Belgium  
Leif Katsuo Oxenløwe, Technical University of Denmark, Denmark  
Xiaoke Yi, University of Sydney, Australia  

Technical Scope

SC1 – Novel Fibres, Fibre Devices & Amplifiers  
Physics of light propagation in optical fibres  
Optical fibre design, fabrication and characterisation  
Specialty optical fibres for improved transmission performance  
Low-latency fibres and fibres for new wavelength ranges  
Fibre-based devices  
Fibre amplifiers and fibre lasers  
Multimode & multicore fibre and fibre amplifiers  
Highly nonlinear fibres and their applications  
Fibres for sensing applications  

SC2 – Photonic Devices & Technologies  
Novel material platforms and structured materials  
Integrated III-V devices  
Design, fabrication and characterisation of novel integrated devices and functionalities  
Detectors and sources, directly modulated lasers and VCSELs  
Silicon and hybrid III-V/silicon photonics  
Nanophotonics  
Optoelectronic devices  

SC3 – Photonic Integrated Circuits, Assemblies & Packaging  
Large-scale photonics integrated circuits  
Packaging of devices, testing of performance and reliability  
Co-packaged optical and electronic ICs (2D, 2.5D and 3D)  
System-on-a-chip (SoC) and on-chip networks  
Advanced analog and digital electronic/optical co-integrated circuits  
Photonic circuits for Neuromorphic applications  
Sources and detectors for quantum communication systems  
Nonlinear waveguides for optical signal processing  
Photonic Integrated Circuits for Artificial Intelligence  
Reconfigurable Photonic Integrated Circuits  

SC10 – Architecture, Control & Management of Optical Networks  
Chair: Reza Nejabati, University of Bristol, UK  
Thomas Bauschert, Chemnitz University of Technology, Germany  
Jiajia Chen, Chalmers University, Sweden  
Hideaki Furukawa, NICT, Japan  
Tom Issenbuth, Huawei, USA  
Raul Muñoz, CTC, Spain  
Yuan Pointurier, Huawei, France  
Emilio Riccardi, Telecom Italia, Italy  
Marco Ruffini, Trinity College Dublin, Ireland  
Gangxiang Shen, University of Soochow, China  
Jesse Simarani, Nokia Bell Labs, USA  
Anna Tzanakaki, University of Athens, Greece  
Raimena Veisliani, Ericsson, Norway  

CLEO®/Europe Focus Meeting

Quantum Photonics  
Co-Chair: Patrick Maletinski, University of Basel, Switzerland  
Co-Chair: Philipp Treutlein, University of Basel, Switzerland  
Yiwen Chu, ETH Zürich, Switzerland  
Hueges de Riedmatten, ICFO Barcelona, Spain  
Christophe Galland, EPFL, Switzerland  
Steve Lecomte, CSEM, Switzerland  
Tilman Pfau, Universität Stuttgart, Germany  
Jeff Thompson, Princeton University, USA  
Thomas Volz, Macquaire University, Australia  

Novel Photonic Materials & Effects  
Co-Chair: Anna Fontcuberta i Morral, EPFL, Switzerland  
Marta De Luca, Sapienza Università di Roma, Italy  
Alexandros Emorbas, ETH Zurich, Switzerland  

Emerging Photonic Devices, Technologies & Applications  
Co-Chair: Giacomo Scalari (Co-Chair), ETH Zurich, Switzerland  
Ileana-Cristina Banea-Chelmus, EPFL, Switzerland  
Stephane Kena-Cohen, École Polytechnique de Montréal, Canada  
Marco Peccianti, Sussex University, UK
SC4 – Techniques for Digitally Enhancing Optical Communication
Algorithms for DSP in optical transmission systems
Experimental demonstration of digital signal processing
Design, implementation & implications of reduced complexity
DSP algorithms
Optical MIMO DSP
Machine Learning based DSP for optical transmission

SC5 – Theory of Optical Communications
New transmission system modelling methods
Capacity, reach, flexibility limits of optical transmission systems
System level implications of physical impairments and impairment mitigation techniques
Novel error correction coding
Advanced data encoding and signal shaping
Information theory for optical communications
Modelling and design of digital signal processing

SC6 – Optical Transmission Systems
Lab/field demonstrations of optical transmission links deploying novel fibres, devices, subsystems and multiplexing techniques
Link system demonstrations using novel signal modulation techniques
Analog and nonlinear signal processing subsystems demonstrating transmission enhancements
Multiplexing and demultiplexing subsystems for improved transmission
Demonstration of spatially multiplexed transmission links

SC7 – Core & Metro Networks
Core, metro and converged networks
Long reach and high capacity transport optical networks
Underwater networks and cable deployment
High connectivity node architectures including protection and failure recovery
Network deployments and field trials
Inter data centres interconnect networks
Subsystems for network functionalities (2R/3R regeneration, OADMs, OXCs, …)
Optical performance monitoring techniques and subsystems
Optical switching and routing in long haul and core networks

SC8 – Access, Indoor & Short-Reach for Data Centres and Mobile Networks
Fibre-to-the-premises (FTTx) and optical access networks
Passive optical networks
In-building optical networks
Intra data centre interconnect networks
High performance computer networks
Backhaul, midhaul and fronthaul networks for mobile applications
Highly parallel network and interconnect demonstrations
Photonics for Cloud and low latency services
Optical switching and routing in short-reach networks

SC9 – Photonics for RF & Free-Space Optics Applications
Microwave Photonics subsystems
Millimetre-wave and THz photonics signal generation/detection
Demonstration of optics-based THz wireless subsystems
Demonstration of analog radio-over-fibre systems for 5G and beyond
Optical wireless communication (subsystems and networks)
LiFi and VLC communication networks
Satellite photonic communication links
Lab/field demonstration of free-space optical wireless transmission
Photonic wired/wireless communication network solutions

SC10 – Architecture, Control & Management of Optical Networks
Control, orchestration, and management of optical networks
Optical network architectures, design and modelling
Planning and scaling of hybrid optical/optoelectronic networks
Machine learning and artificial intelligence for advanced optical networking, performance monitoring and advanced network troubleshooting
Integration of optical transmission network layers with higher-layer network services
Network reliability, survivability, security and disaster recovery
Driven optical layers for network functions virtualization and software defined network applications

CLEO®/Europe Focus Meeting
Quantum Photonics
Quantum optics and quantum communication
Quantum sensing and metrology
Photonic quantum computing and simulations
Quantum nanophotonics
Quantum optomechanics
Quantum interfaces
Coherent transfer from the optical to the microwave domain
Quantum memories for photons
Quantum networks
Quantum light sources and detectors
Theory of quantum communication systems
Demonstration of quantum communication systems
Quantum cryptography lab/field demonstration

Novel Photonic Materials & Effects
2D photonic materials
Metamaterials and metasurfaces
Nanophotonic materials
Novel nonlinear optical materials
Plasmonic effects
Optical memristive effects

Emerging Photonic Devices, Technologies & Applications
Ultrafast devices and technologies
Plasmonic devices
Frequency combs and microresonators
Optical computing
Photonic memristive devices and circuits
Non-reciprocal photonics
Inverse design for photonic devices
Nanolasers
Workshops

WS01 • Optical Networks • Will They Destroy the Planet or Save Humanity?
Sunday, 18 September, 14:00–17:30, San Francisco

Exponential growth is not sustainable, and the once long-term problems of climate change are becoming rapidly short-term problems affecting resource depletion, waste generation, general pollution and increasing prevalence of natural disasters. This workshop examines the green credentials of the optical communications industry, and looks at initiatives and directions towards a more sustainable future.

Today’s networks focus on high-end performance and end-user experience. Tomorrow’s networks must also balance energy efficiency with varying traffic-load, and designs focused on sustainability.

The workshop precedes the Nobel plenary talk of Didier Queloz on Exoplanet Discovery, and in contrast to traditional ECOC workshops, will be open to the general public. There will be plenty of opportunity for thought-provoking discussion and questions!

Organisers Chris Fludger, Infinera GmbH, Germany
Fabrice Bourgart, Orange Labs, France

Topics & Speakers
The Big-Picture
Klaus Grobe, ADVA Optical Networking SE, Germany

Re-use, Reduce, Re-cycle
Florian Doussot, Orange, France

Give Me Moore for Less!
Kishore Kota, Marvell, USA

A Disruption in the Network
Johan Bäck, Infinera, Sweden

Big-Data vs Intelligent Data
Dan Kilper, Trinity College Dublin, Ireland

Are Optical Networks the Solution for Energy Hungry Data Centers?
Chongjin Xie, Alibaba Cloud, USA

Are We Willing Participants or Do We Need to Be Dragged Screaming to the Table?
Jean-Luc Lemmens, IDATE, France

WS02 • Role of Optical Network for Split Computing Between Edge and Cloud in Support of Ultra Low Latency Services
Sunday, 18 September, 09:00–12:30, Samarkand + Osaka

Mobile applications are evolving rapidly, requiring accurate and highly sophisticated computational methods such as machine learning (ML) techniques. Their processing power requirements cannot be supported in a mobile device with reasonable latency and energy consumption.

Currently these applications are designed based on hosting all computation in high-end remote cloud servers. Queries generated from users’ mobile devices are sent to the cloud for processing. In this approach, large amounts of data (e.g., images, video and audio) are uploaded to the server via multiple networks, resulting in high latency and energy costs.

To overcome these issues, emerging solutions are designed to host all the computation at the edge computing servers close to users. The drawbacks of this approach include limited computing capability at the edge, network delay and its variation (wireless network) and complexity to handle mobility of users from edge to edge.

Another recent technological solution is Split Computing. In this approach, computing tasks are split and executed between the mobile devices, the edge compute resource and the cloud.

Realizing split computing requires advanced techniques for breaking a computational task, e.g., Deep Neural Network (DNN) into head and tails ends for execution in mobile, edge and cloud. It also requires close orchestration between application and a network in order to provide low latency connectivity between different parts of a computing tasks split across mobile, edge and cloud data center. This becomes even more challenging when users are mobile and in highly dense scenarios.

This workshop aims to discuss challenges and possible solutions as well as opportunities for optical technologies for realizing next generation edge computing based on split computing. The workshop includes a series of position talks from industry and academia followed by a panel discussion.

Organisers Reza Nejabati, University of Bristol, UK
Andrew Lord, BT, UK

Topics & Speakers
Federated and Split Computing at the Edge
Mahesh Sooriyabandar, Toshiba Europe, UK

6G Boosted Split-computing
Joan Pujol Roig, Samsung R&D, Korea

Optical System Optimization Trade-offs in Low Latency (and Low Power) DCI and Edge
Loukas Paraschis, IEEE Communication Society, USA

Complexity, Accuracy and Delay Tradeoff in Split Computing for Distributed Computer Vision
Marco Leverato, UC Irvine, USA

Intelligent Cloud & Edge Dynamic Orchestration of Demanding 6G Services
Xenofon Vassilikos, University of Bristol, UK

Transport SDN & Orchestration in Support of Split Computing
Ramón Casellas, CTTC, Spain

Low Power Backhaul Networking in Support of Extreme Edge Computing
Andy Reid, BT, UK

Centralize What You Can, Distribute What You Must? – Strategies for Distributing Compute Functions
Jörg-Peter Elbers, ADVA, Germany

Time to Transport and Time to Compute, Could It Be Time to Care About Time?
Sebastian Bigo, Nokia Bell Labs, France

Can New Photonics Technologies Transform the Landscape of Edge Computing and Split Computing? Where is the Balance?
Ben Yoo, UC Davis, USA

Scaling AI at the Edge – Scenarios in Telco, Automotive and Industry 4.0
Laurent Scharcs, IBM, USA

Combining Edge and Central Cloud Compute: An Enabler for 6G Services
Anna Tzanakaki, NKUA, Greece
WS03 • The Path Towards Terabit/s PONs: Enabling Multi Gbit/s Data Rate Services
Sunday, 18 September, 14:00–17:30, Samarkand + Osaka
It is anticipated that new use cases will become the main drivers behind the need for emerging PON technologies. Applications such as mobile front haul (MFH) and mobile back haul (MBH) for 5G and future 6G networks will require PONs with capacities well beyond those outlined in the ITU recommendation on Higher Speed PONs. The conventional IM/DD approach based on NRZ is already close to its limits in terms of launch power levels or receiver sensitivity, motivating research into new directions in order to reach network throughput beyond 50 Gbit/s per wavelength. The workshop covers these topics with two sessions of presentations. The first session will discuss solutions to further scale throughput and improve operational aspects using existing IM/DD approaches. The latest recommendations for Higher Speed PON will be presented covering 50G upstream challenges and limitations, as well as TWDM evolution and use cases.

In addition, the evolution of IM/DD PON systems will be discussed including: how to bring flexibility in PONs, DSP energy consumption considerations and possible developments in advanced DSP. Insights on future PONs based on new transceiver architectures will be presented in the second session, which will explore advances at the device and sub-system level that are required to increase PON capacity beyond 100 Gbit/s per wavelength. The discussion will also consider how technologies developed for data centre and metropolitan networks (integrated photonics, coherent transmission, multi-carrier systems, DSP, etc.) can be adapted for PON applications.

Organisers Fabienne Saliou, Orange, France
Liam Barry, Dublin City University, Ireland
Robert Borkowski, Nokia Bell Labs, USA

Topics & Speakers
What’s Going on with Higher Speed PON Standards in ITU-T?
Derek Nesset, Huawei Technologies, Germany

NG-PON2: Lighting the FiOS
Jun Shan Wey, Verizon, USA

Flexibility in PON - Enabler for New Use Cases
Rene Bonk, Nokia Bell Labs, Germany

Energy-efficient DSP for High Speed PONs
Lilin Yi, Shanghai Jiao Tong University, China

Advanced DSP for IM/DD PON
Tom Wettlin, Kiel University, Germany

Will Coherent Optics Change the Game of Future PON Market?
Zhensheng Jia, Cable Labs, USA

Transceiver Options for High Speed Coherent PON
Seb Savory, University of Cambridge, UK

Analog Coherent Receiver Architectures for PONs/Access Networks
Clint Schow, University of California, Santa Barbara, USA

Device Integration for NGPON
Christopher Doerr, Aloe Semiconductor, USA

100G+ PON is Here – FDM Enables Continued Capacity Growth over Existing Fiber Infrastructures
Antonio Napoli, Infinera, Germany

WS04 • Adaptive Everything! Do Optical Networks Really Need More Flexibility?
Sunday, 18 September, 09:00–12:30, Singapore
As state-of-the-art transmission equipment pushes towards higher spectral efficiencies and symbol rates, there is an equally important drive for flexibility in optical networks. In response to this, highly flexible bandwidth allocation, adaptive constellation entropy (or spectral efficiency), and machine learning-based DSP paradigms are all being considered for future network deployments. However, adaptivity increases system and network complexity. Could other solutions be more cost-effective or practical?

In this session, a cross-section of representatives from industry and academia will give their take on the questions of adaptivity and flexibility in future optical networks.

The workshop will be divided into four sections:
- Crystal balling: how to make a deployment decision today based on the next 20 years’ needs?
- Do we need more (or less!) adaptivity in optical networks?
- Capacity without complexity: can we meet capacity demands with better fiber/cables, alone?
- Reality versus fiction in autonomous networks

Organisers Lidia Galdino, University College London, UK
Domanic Lavery, Infinera, Canada
Segejs Makovejs, Corning Inc., USA

Topics & Speakers
Crystal Balling: How to Make a Deployment Decision Today Based on the Next 20 Years’ Needs?
Glenn Wellbrock, Verizon, USA

400ZR and OpenZR+: Enabling New Network Architecture Optimization
Angela Finn, Cisco, USA

Challenges of Operating an Adaptive Zero Margin Network
Milen Paskov, Meta, UK

Long Haul Adaptive Networking Strategies
Pierre Mertz, Infinera Inc., USA

Optical Network Flexibility: A Cloud Operator’s Perspective
Mark Filer, Google, USA

Is Multi-core Fiber Ready for Deployment?
Tetsuya Hayashi, Sumitomo, Japan

Applications of Relevance for SDM: Fiber and Cable Perspective
Merrion Edwards, Corning, UK

Towards Zero Margin Networking: What is Possible and What is Desirable?
Seb Savory, Cambridge University, UK

Adaptive Networks Exploiting Learning-assisted Physical Layer Modelling
Qunbi Zhuge, Shanghai Jiao Tong University, China

Fully Autonomous Networks: Why Not Close the Loop?
Robert Keys, Ciena, Canada

Do Network Automation and Security Go Hand in Hand?
Marija Furdek Prekratic, Chalmers University, Sweden

WS05 • Are Multi-band Optical Networks Simple Extensions of Traditional C-band Networks?
Sunday, 18 September, 14:00–17:30, Singapore
Multi-band (MB) expands the available capacity of optical fibres beyond traditional C and/or C+L bands by enabling transmission within S, E, and O bands - translating into a potential 10x capacity increase. MB networking raises challenges from both system and network perspectives.
From the point of view of the former, MB networks require new key components, such as optical amplifiers, transceivers, and possibly MB reconfigurable add/drop multiplexers (MB ROADMs). For the latter, MB networks require an improved modelling of the physical layer, novel algorithms for monitoring and correcting of the nonlinear impairments as well as adapted node and network architectures to fully exploit MB along with the required abstractions for network planning, configuration, and control.

However, do we have to consider MB networks as simple extensions of traditional C-band networks? For example, how ROADMs look like in MB networks supporting hundreds of wavelengths? Do we need ROADMs with few GHz switching granularity or MB filterless subsystems might be adequate in most of the cases? And from a networking perspective, do we have to consider single domains of transparency or remove boundaries between network domains thus reducing electronic intermediate terminations? How SDN control will evolve to control such end-to-end-domain-less architecture?

This workshop will first present the state-of-the-art and future trends of MB devices and technologies. Furthermore, it will discuss when and where MB networks are expected to be introduced first, including the operators’ strategies regarding the adoption of MB networks. Then, the workshop will discuss what the implications of the availability of MB are, including redesign of the end-to-end architecture(s), MB switching technologies and SDN control, beyond traditional approaches.

**Organisers**
- Raul Muñoz, CTTC, Spain
- Filippo Cugini, CNIT, Italy
- Óscar González de Dios, Telefónica I+D, Spain

**Topics & Speakers**

**Perspective of Multi-Band in Tim Networks**
Emilio Riccardi, Telecom Italia Mobile (TIM), Italy

**Challenges for Wavelength Switches in Multi-band ROADMs**
David Neilson, Nokia, USA

**Challenges for Introducing Multi-band Amplification in Existing C-band Networks**
Lutz Rapp, ADVA, Germany

**Benefits of Multiband Optical Networks from a Telecom Operator's Perspective**
Emilio Hugues Salas, BT, UK

**Beyond C+L-band Systems: Is There a Solid Business Case?**
Joao Pedro, Infinera, Portugal

**Network Upgrades Exploiting Multi Band**
Nicola Sambo, SSSUP, Italy

**Expanding Disaggregated and Open Transport for Metaverse Ready Networks**
Arturo Mayoral, Telecom Infra Project, Spain

**Control Plane Challenges for Optical Multiband Networks**
Ramon Casellas, CTTC, Spain

**WS06 • F5G and Evolution Towards F6G**
Sunday, 18 September, 09:00–12:30, Sydney

With the fiber-to-everywhere vision, the European Telecommunications Standards Institute (ETSI) established at the beginning of 2020 an industry specification group (ISG) dedicated to the definition and specification of the 5th generation fixed network (F5G). Since then, the first release of 14 use cases of F5G have been published, and the second release of 18 use cases is forthcoming. Reaching deeper to final access points, optical fibre will realize its full potential to support a fully connected, intelligent world with high bandwidth, high reliability, low latency, and low energy consumption. This workshop is intended to provide a timely update on the new progresses made on F5G. Particularly, proof-of-concept demonstrations of several use cases published in F5G Use Case Release 1, such as cloud virtual reality (Cloud-VR) and fiber-to-the-room (FTTR), will be presented. In addition, the emerging use cases to be released by early 2022 will be described. Among them are: industrial PON, rural broadband, and edge/cloud-based control of industrial robots and automated guided vehicles etc. This workshop also aims to encourage stimulating discussion on the future evolution toward F6G. Specifically, new application areas, support for even better quality network enabling novel applications, and improving the users experience. The topics of this workshop include:
- F5G use cases with focus on proof-of-concept demonstrations
- FSG for better supporting Industry 4.0 and industrial internet of things (IIoT)
- Enabling Optical Technologies for low-latency broadband communication
- Enabling Optical Technologies for energy-efficient broadband communication
- Harmonized communication and sensing/positioning

**Space and Satellite Optical Communications**

**Evolution towards F6G: How optical network would look like in 2025 and 2030**

**Support for novel applications and better user experience**

**Organisers**
- Philippe Chanclou, Orange Labs, France
- Xiang Liu, Huawei Technologies, China

**Topics & Speakers**

**F5G Update: Second Release of Use Cases by the ETSI**
Luca Pesando, Chair of ETSI ISG-F5G, Telecom Italia, Italy

**F5G Use Cases for Industrial Automation**
Johannes Fischer, Fraunhofer HHI, Germany

**Real-Time Demonstration of Fiber-to-the-Room for >1Gb/s Home Networking**
Gaël Simon & Fabienne Saliou, Orange, France

**Optical Network Evolution Oriented at Computing Force Network and Metaverse**
Han Li, China Mobile, China

**Evolution of the Fiber Infrastructure for Fixed Networks**
Adrian Amezcua, Pysmsian, France

**Dynamic Satellite Optical Communication Networks**
Yongli Zhao, Beijing University of Posts and Telecommunications, China

**Innovative Coherent Point-to-Multipoint Technologies for Aggregation Networks**
David Welch, Infinera, USA

**Opportunities and Challenges in the Evolution Beyond F5G**
Ed Harstead, Nokia, USA

**Update on the Innovative Optical and Wireless Network (IOWN) Initiative for Fixed Networks**
Jun-ichi Kani, NTT, Japan

**F5G Advanced & Beyond: Vision, Mission and Pace**
Frank Effenberger, Vice Chair of ETSI ISG-F5G, Futurewei, USA

**F6G: Vision, Key Enabling Technologies and Research Topics**
Jean-Luc Beylat, Nokia, France
WS07 • Which Technologies Will Be Needed for 6G?
Sunday, 18 September, 14:00–17:30, Sydney

This workshop will open a discussion trying to answer how different technologies can cope with the Key Performance Indicators and Key Valuable Indicators or social impact effects considered in 6G, including how to contribute to walk the path for achieving the Sustainable Development Goals. From architectural issues identifying the needs on different scenarios to the solutions proposed by the different technologies including Transport and Access Networks, Optical Wireless Communications, THz, hybrid systems and Power over Fiber among others.

Organisers Carmen Vázquez, Universidad Carlos III Madrid, Spain
Dimitra Simeonidou, University of Bristol, UK
Zabih Ghassemlooy, Northumbria University, UK
Paulo Monteiro, University of Aveiro, Portugal

Topics & Speakers

End-to-end System Requirements for 6G from a Service Provider’s Perspective
Arjun Parekh, British Telecom, UK

Transport Network in the Path for 6G
Paola Iovanna, Ericsson, Italy

Low Latency Access: Can it Be Achieved over PONs and Network Virtualisation? Is There a Role for Free Space Optics?
Marco Ruffini, Trinity College Dublin, Ireland

Multi-user Tb/s Optical Wireless Systems for 6G
Jaafar Elmigrhani, University of Leeds, UK

Opportunities and Challenges of Power-over-Fiber in 6G Networks
Motoharu Matsuura, University of Electro-Communications, Japan

Why Optical Wireless Communication (OWC) is Ready for 6G
Harald Haas, University of Strathclyde, UK

Developing Next-Generation Wireless for 6G: Ultra-High Capacity Optical Solutions
Fernando Guiomar, Instituto de Telecomunicações, Portugal

The Role of Opto-electronic Co-integration for 6G Systems and Networks
Idelfonso Tafur, Eindhoven University of Technology, Netherlands

Terahertz Technology for Seamless Networks
Tetsuya Kawanishi, Waseda University, Japan

AI-Enabled Intelligent Visible Light Communications
Nan Chi, Fudan University, China

WS08 • Life Above 100-GHz: Terahertz Device and System Challenges and Opportunities
Sunday, 18 September, 09:00–12:30, Rio

RF Photonic systems handle photonic and electromagnetic waves, being the only technology today enabling continuous generation of Terahertz signals where vast amounts of bandwidth are available. However, as frequencies increase, also increases the complexity of the characterization and packaging of these systems. Current efforts are towards the development of standardized packaging solutions within Packaging Pilot Lines, providing fiber array access ports and multiple DC electrical connections. However, RF applications are still lagging behind, considering that Beyond 5G aiming to move at frequencies above 100 GHz. This is a major problem since there are few RF connector solutions at higher frequencies, with coaxial standards reaching up to 110 GHz (1-mm connector) and rectangular waveguides segmenting the spectrum into bands defined by flange size. In this workshop we will discuss state-of-the-art for characterization and packaging of photonic Terahertz systems.

This workshop is organized around the TERAmeasure Pathfinder EU project (www.uc3m.es/research/terameasure), developing photonic-driven technologies for Terahertz instrumentation. The goal is to develop a photonic-based Vector Network Analyzer operating beyond 1 THz. The workshop provides an overview of why we need these systems, and the current challenges that are faced when developing devices and systems operating above 100 GHz, with key speakers addressing the different components (high-speed photodiodes, detectors), the integration of antennas and the assembly challenges.

Organisers Guillermo Carpintero, Universidad Carlos III de Madrid, Spain
Dmitry Lyubchenko, KTH Royal Institute of Technology, Sweden

Topics & Speakers

Outlook for Beyond 5G Communications: Will 100-GHz Systems Be Required?
Atsushi Kanno, National Institute of Information and Communications Technology, Japan

Demonstrations of THz Transmission Technology Based on Photonics for Future THz-band Indoor Network
Seung-Hyun Cho, ETRI, Korea

Dielectric Rod Waveguides for Ultra-broadband Photonic Phased Array Antennas and THz Interconnects
Muhsin Ali, Universidad Carlos III de Madrid, Spain

Broadband PIN-photodiodes and Photomixing Receivers for Photonic THz Links
Robert Kohlhaas, Fraunhofer HHI, Germany

The Advancement of THz Test and Measurement Equipment for 5G, 6G and Beyond
Jeffrey Hesler, Virginia Diodes, USA

Challenges and Demands for Wafer-level Probing of Photonics Devices
Dan Rishavy, Form Factor, USA

WS09 • Moving from Optical Components in RAN to Optical Components for RAN
Sunday, 18 September, 14:00–17:30, Rio

Generic optics, developed for applications different from RANs, may not fit the requirements of the mobile transport network. Optical components natively conceived for radio access and based on technologies driven by its requirements (right optics at the right time and the right cost) would accelerate the pace at which RANs are deployed and decrease the relative cost of the optics as part of the total RAN solution. All industry players (communication service providers, system vendors, and optical pluggable vendors) can gain from a cooperative approach where a common and shared view of the features that the RAN requires from optical components is built first. This fosters a bigger and less fragmented market when the usual competition phase starts. It would make it easier, and with lower risk, to estimate and plan the evolution
of networks and products. Moreover, R&D work can be done faster and more effectively with reduced risk and a better ecosystem with more stable and sustainable supply chains can be put in place. The MOPA (Mobile Optical Pluggable Alliance) is an example of this new approach.

In the workshop, major industries, network operators and representatives of the research community will provide their view, pointing to solutions to fill the current gaps in standardization and technology development, accelerating the deployments of 5G transport networks and making them more cost-effective.

Organisers
Fabio Cavaliere, Ericsson, Italy
Ronald Heron, Nokia, USA

Topics & Speakers
Optical Access Network for RAN: Current State and Possible Evolution Paths
Junichi Kani, NTT, Japan

Unlocking Open RAN Opportunities with Optical Networks
Philippe Chancou, Orange, France

Multi-Operator Network Sharing over Open Optical Networks
Edward James Echeverry Zuleta, Telefonica, Spain

Intersection of RAN Design and Optics
Mark Watts, Verizon, USA

RAN as One Service in a Metro Optical Network
Andrew Lord, BT, UK

Capacity Expansion in Fronthaul Networks: Opportunities and Challenges
Antonio Tartaglia, Ericsson, Italy

Extending Coherent Technology to the Radio Unit with P2MP Intelligent Coherent Pluggables
Antonio Napoli, Infinera, Germany

Mobile Transport Requirements: TCO for Fronthaul – Options and Solutions - Short Complete Review
Lieven Levrau, Nokia, France

Open Optical Edge Connecting Mobile Access Networks
Jim Zou, ADVA, Germany

Aligning MOPA Blueprints with Industry Standards
Kenneth Jackson, Sumitomo, USA

Opportunities and Challenges of High-Bandwidth Components for RAN
Marc Reig Escalé, Versics, Switzerland

Tunable Optics for Front-haul Networks
David Lewis, Lumentum, USA

Short Reach Communication: Is Finally Time for Coherent Transceivers?
Luca Poti, CNIT, Italy

Smart Wavelength Tunable Transceivers for RAN Applications
Ken Cockerham, II-VI, USA

WS10 • (On-chip) Frequency Combs from NIR to THz
Sunday, 18 September, 09:00–12:30, Boston

In this workshop, we will be discussing the last trends and advancements of optical frequency combs, spanning a broad frequency range from NIR to THz, with an on-chip twist. Several approaches to comb generation (fiber-based, Kerr combs, QCLs and ICLs, non-linear conversion, supercontinuum…) and characterization will be presented. Themes such as soliton formation, spectroscopic applications, device integration as well as hybrid approaches to comb operation will be debated. The workshop will feature 15 minutes-long presentations from the individual panellists as well as a final, half-hour long Q&A panel interactive session to promote discussion and exchange views on the different proposed approaches.

Organiser
Giacomo Scalari, ETH Zurich, Switzerland

Topics & Speakers
Kerr Nonlinearities in Quantum Cascade Lasers: From Phase Turbulence to Solitons
Benedikt Schwarz, TU Wien, Austria

Combs Based on Phase Modulated Recirculating Loop from Fibre to Monolithic Integration: Challenges and Solutions
Cyril C. Renaud, University College London, UK

Quantum Cascade Frequency Combs: Solitons and Short Pulses
Jérôme Faist, ETH Zurich, Switzerland

Self Emergent and Robust Cavity Soliton Microcombs
Alessia Pasqua, University of Sussex, UK

Broadband Mid-Infrared Supercontinuum Generation on a CMOS-based Chip
Christian Grillot, INL – École Centrale de Lyon, France

Electrically Pumped Mode-locked Lasers on a Silicon and Silicon Nitride Platform
Bart Kuyken, Universiteit Gent – imec, Belgium

Supercontinuum Generation: Shaping a Spectrum for MIR Applications
Christian Lafforgue, EPFL, Switzerland

Microringaator Soliton Frequency Combs for THz Generation
Pascal Del’Haye, Max Planck Insitute for the Science of Light, Germany

WS11 • Quantum Communication • Hype or Ripe? From QKD Networks to a Global Quantum Internet
Sunday, 18 September, 14:00–17:30, Boston

Quantum technology is subject to intense academic and industrial debate due to its prospects as a game changer in the fields of secure communications, computation and sensing. However, there has been little action taken up to now when it comes to practical field-deployment as bearer for “live” end-user applications. Extending these networks to serve as a Quantum Internet in an emerging computing realm poses no smaller challenge.

We will discuss the findings of recent field-installations conducted during first pilots supporting the ramp up of the EuroQCI (European Quantum Communication infrastructure) initiative, aiming to establish a Quantum Internet by the end of the decade – not only to ultimately contribute to data security but also to unleash new concepts such as distributed quantum computing and quantum sensing networks.

The workshop is divided in three sessions: Presentations of Session 1 will set the scene by highlighting the findings of current QKD network deployments conducted during the past 12 months and the lessons learnt for the expansion towards a Quantum Internet. Session 2 will then focus on the technologies and feasibility to bridge longer distances for extended-reach quantum networks. Together with Session 3,
it will also put focus on the controversy between a quantum repeater versus a repeaterless approach. Finally, Session 3 will elaborate on the applications of a global Quantum Internet and the timeframe for its practical deployment.

Organisers
Hannes Hübel, Austrian Institute of Technology (AIT), Austria
Bernhard Schrenk, Austrian Institute of Technology (AIT), Austria
Helmut Griesser, ADVANCE Optical Networking GmbH, Germany

Topics & Speakers
Integrated Dynamic Quantum Networks for Secure Communications and Quantum Internetworking
Rui Wang, University of Bristol, UK

The BT Commercial London Quantum QKD Network and Evolution Towards the Quantum Internet
Andrew Lord, BT, UK

Dynamic QKD as an Application Example in the HellasQCI Ecosystem
George Kanellos, University of Athens, Greece

DemoQuanDT – the Quantum Communication Test Link in Germany
Oleg Nikiforov, Deutsche Telekom, Germany

Quantum Communication via Satellites
Christoph Marquardt, Friedrich-Alexander-Universität Germany

The Route to Quantum Repeaters Based on Quantum Memories
Tracy E. Northup, University of Innsbruck, Austria

Hollow Core Fibers: Savior or Death for Quantum Repeaters?
Francesco Poletti, University of Southampton, UK

Developments of Quantum Networks
Jesse Robbers, Quantum Delta, Netherlands

Applications for the Quantum Internet
Inder Monga, ESNet, USA

Addressing Technological Challenges of Quantum Computing Hardware: the Rise of Integrated Photonics Technologies
Ségoîlène Olivier, CEA-Leti, France

WS12 • Heterogeneous Photonic Integrated Circuits
Sunday, 18 September, 09:00–12:30, Shanghai
This workshop will discuss the technologies for heterogeneous photonic integrated circuits and the applications requiring them. The strengths and weaknesses of the different technologies are addressed and a match will be sought between current/future applications & existing technologies.

Organisers
Gunther Roelkens, Ghent University - imec, Belgium
Martinijn Heck, TU/e, Netherlands

Topics & Speakers
Photonic Multi-Chip Integration Enabled by Photonic Wire Bonds (PWB) and 3D-Printed Microlenses
Sebastian Skacel, Vanguard Automation GmbH, Germany

High-Precision Flip-Chip Bonding of InP Lasers on Silicon Photonics
Joris Van Campenhout, imec, Belgium

Challenges and Advantages of III-V Integration in a Foundry Environment
Oleg Martynov, Tower Semiconductor, USA

Micro Transfer Printing to Allow for Heterogenous Components Integrated on a Single Substrate
David Gomez, X-Celeprint, USA

Heterogeneous Integration of Quantum Dot Photonics for Optical Connectivity
Alan Liu, Quintessent, USA

III-V Active Devices Selectively Grown on Patterned SOI by Lateral MOCVD
Kei May Lau, Chinese University of Hong Kong, Hong Kong

Heterogeneous Photonic Integration for Datacom and Optical Sensor Applications
Jonathan Doylend, Intel, USA

Hybrid Lasers and Electro-absorption Modulators in Multi-micron Waveguide Silicon Photonics and the Application
Hua Yang, Rockley Photonics, Ireland

2.\(\times\)\(\mu\)m GaSb/Si Laser Spectrometers
Augustinas Vizbaras, BROILIS, Lithuania

Requirements for Heterogeneous Photonic Integrated Circuits for Modern Automotive LiDAR
Stanislav Aksarin, Scantinel, Germany

Heterogeneous Photonics at DARPA
Gordon Keeler, DARPA, USA

Heterogeneous Integration for Single-photon Quantum Technologies
Leonardo Midolo, Niels Bohr Institute, Denmark

WS13 • Photonic and Electronic Co-integration Solutions
Sunday, 18 September, 14:00–17:30, Shanghai
By following the standard CMOS fabrication processes in the microelectronics industry, silicon or III/V photonics are emerging as the platforms of choice for large-scale photonic integration circuits (PICs) that offer the well-known advantages of low-cost at high-volume and high yield as well as scalability, respectively. However, co-integration of electronics with photonics is becoming critical for actually exploiting the high bandwidth, reduced power consumption, further shrink footprint and most importantly guaranteeing all this at lower cost. Novel co-integration schemes and further improved functionalities are needed to go beyond the limitations posed by the intrinsic material capabilities and speed imitations at the electro-optical interfaces. This workshop provides opportunities to discuss and debate the latest technologies on which photonics and electronics can be co-integrated and synergically operate to satisfy requirements in bandwidth and speed. The aim of this workshop is to compare performance, pinpoint limitations and stimulate the envisioning of novel schemes for future technology development.

Organisers
Xuhan Guo, Shanghai Jiao Tong University, China
Patty Stabile, TU/e, Netherlands
Lars Zimmermann, IHP, Germany

Topics & Speakers
Integrating Monolithic InP Photonic Circuits with High-speed Electronics
Kevin Williams, TU/e, Netherlands

Dense Integration of Photonics and Electronics Through Micro-transfer Printing
Peter Ossieur, imec, Belgium
MASSTART: Path for High Volume Manufacturing of Data Center Transceivers
Tolga Tekin, IZM, Germany

Perspective on Silicon Photonics Foundry
Anthony Yu, GLOBALFOUNDRIES, USA

Electronic-Photonic Design Automation
James Pond, Ansys, Canada

Co-integration for Data Center Transceivers Beyond 400G
Hanjo Rhee, Sicoya, Germany

Integration of Photonics and Electronics for Coherent Applications
Mehrdad Ziari, Infinera, USA

Applications and Demonstrations of an Optic-Electronic-Optic Interferometer
Sebastian Randel, Karlsruhe Institute of Technology, Germany

WS14 • Linear Optics – A Solution for Efficient AI, Hard Problems Solving, Quantum and Microwave Technologies?
Sunday, 18 September, 09:00–12:30, Delhi

This workshop aims to discuss the recent advances in Universal Linear Optics and their transfer into Photonic Integrated Circuits for addressing a broad range of applications, including, but not limited to, machine learning, neuromorphic photonics, hard problem solving, quantum photonics, programmable photonics and microwave photonics.

Organisers
Nikos Pleros, Aristotle University of Thessaloniki, Greece
Francesca Parmigiani, Microsoft Research Ltd., UK
Angelina Totovic, Celestial AI, USA

Topics & Speakers
Neuromorphic Photonics using Diffractive Optics and Lattice Filters
Folkert Horst, IBM Zurich, Switzerland

Universal Linear Optics in Neuromorphic Photonics
Apostolos Tsakyridis, Aristotle University of Thessaloniki, Greece

Multi-wavelength Silicon Photonic Neural Networks and Applications
Chaoran Huang, Princeton University, USA

Amplitude Modulation in Linear Optical Circuits for AI inference
Johannes Feldmann, Saliens Labs, UK

Neuromorphic Silicon Photonics: Inference and Training, Classical and Quantum
Bhavin Shastri, Queens University, Canada

Photonic-electronic Accelerators for Machine Intelligence
Volker Sorger, Optelligence, USA

Solving Hard Optimization Problems with Light
George Mourgas-Alexandris, Microssoft Research, UK

Plug-and-play Universal Photonic Processors for Quantum Information Processing
Caterina Taballione, Quix Quantum, Netherlands

Integrated Microwave Photonics PIC Platform: Realization of an Optical Beamformer
Chris Roeloffzen, LioniX, Netherlands

Programmable Photonics
Daniel Perez-Lopez, iPronics, Spain

Silicon Photonics in Programmable Linear Circuitry
Wim Bogaerts, imec, Belgium

WS15 • Emerging Fiber Technologies for Transmission and Amplification
Sunday, 18 September, 14:00 – 17:30, Delhi

The losses of optical fibers have been reduced to ~0.14dB/km and the fiber count in single small-diameter cables has rapidly increased to ~6,912 in these days. Uncoupled multi-core fibers and few mode fibers with standard cladding diameter for SDM transmission are intensively investigated for practical use. Hollow-core fibers transmitting over a broad wavelength range compete with standard silica fibers with respect to attenuation. Adding new materials into doped fibers shows the potential to expand transmission window beyond the C+L bands. In this workshop, we discuss the emerging technologies of transmission fibers and optical amplification that will achieve the next major leap in optical communications.

Organisers
Kunimasa Saitoh, Hokkaido University, Japan
Periklis Petropoulos, University of Southampton, UK
Haoshuo Chen, Nokia Bell Labs, USA
Kazunori Mukasa, Furukawa Electric, Japan

Topics & Speakers
Silica Core Fiber Technologies for Ultimately Low Loss
Takemi Hasegawa, Sumitomo Electric, Japan

Controlling Void in Silica Glass for Ultralow Optical Scattering Loss
Madoka Ono, AGC Inc., Japan

Reducing Loss Beyond Silica by Anti-resonant Fibers
Francesco Poletti, University of Southampton, UK

Recent Progress on O-band Bismuth-doped Fibre Amplifiers
Jayanta K. Sahu, University of Southampton, UK

E and S Band Optical Fiber Amplifiers, Status and Practical Concerns
Lixian Wang, Huawei Technologies Canada, Canada

Scaling Fiber Modal Capacity by Topological Confinement
Siddharth Ramachandran, Boston University, USA

Arbitrary Generation of Spatiotemporal Field
Nicolas Fontaine, Bell Laboratories, USA

OAM Fibers for High-capacity Communications
Leslie A. Rusch, Université Laval, Canada

Investigation of Loss Mechanisms in Few-mode Optical Fibers
Maroun Bsaibes, Université de Lille, France
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Symposia

Mo3/4E • Swiss Symposium – Light & Time
Monday, 19 September, 13:30–17:30, Boston

Switzerland, while a small country, has a long tradition of excellence in Science and Technology with recognized worldwide impact. This tradition is perpetrated by research made in public institutions and cutting-edge technical products developed and commercialized by companies. In this symposium, prominent examples, arranged in an appealing program, will be presented by leading actors. The different subjects, providing a link to current and future optical communication technologies, will cover industrial atomic clocks, time and frequency dissemination in science and industry, brilliant light sources from synchrotron and free-electron lasers, and optical frequency combs as instrument calibrator for exoplanet search.

Organiser  Steve Lecomte, CSEM, Switzerland

Topics & Speakers
How Optical Fiber Networks Contribute to the Realization and to the Dissemination of Improved Time Scales and Reference Frequencies?
Antoine Jallageas, METAS, Switzerland
GPS-over-Fiber: Challenges and Applications
Stephan Hunziker, Huber+Suhner, Switzerland
Atomic Clocks Development at Orolia Switzerland
Nil Almat, Orolia, Switzerland
Quantum Information Processing with Trapped Ions Using Integrated Photonics
Jonathan Home, ETH Zurich, Switzerland
Brilliant Light from Free Electrons
Gabriel Aeppli, PSI, Switzerland
Frequency Rulers for Astronomical Spectroscopy
Ewelina Obrzud, CSEM, Switzerland

Mo3/4H • Symposium on 50 Years of Fibre Optics
Monday, 19 September, 13:30–17:30, Delhi

With a multi-billion kilometre global network enabling the Internet, the social media and the remote working revolutions, and a worldwide production rate exceeding the speed of sound, optical fibres are undoubtedly one of the technological wonders of the last 50 years. The economic impact of modern telecoms-grade optical fibres and their improved optical performance have been driven by the pioneering vision and inventiveness of leading fibre optics researchers.

In this symposium, we will go back in time with some of the protagonists of this 50-year long revolution and we will hear their own recollection of the challenges they faced and the critical inventive steps they took to lay the foundations of present and future optical communications.

This will provide an opportunity for the community to reflect upon the journey so far, use past lessons to overcome present day challenges, and inspire younger generations of researchers to keep thinking creatively despite adversities.

Organisers Francesca Poletti, University of Southampton, UK
Tommy Geisler, OFS, Denmark

Topics & Speakers
Ups and Downs on the Path to Making the First Practical Low Loss Glass Fibers for Optical Communications
Peter Schultz, former Corning Research Manager, USA
Invention of VAD and the Early Efforts in Japan to Reduce Loss Levels
Tatsuo Izawa, former President of NTT Electronics, Japan
The Discovery of the Optical Fibre Amplifier
David Payne, University of Southampton, UK
Ultra-low Loss Optical Fibre and Ultra-high Fibre Count Optical Cable
Hiroo Kanamori, former Sumitomo Research Manager, Japan
New Technologies and Bold Decisions
Peter Cochrane, former BT CTO, UK

Three Decades of Photonic Crystal Fibres
Philip Russell, Emeritus Founding Director, Max Planck Institute for the Science of Light, Germany

Tu3H • IEEE International Network Generations Optics Roadmap, 1st Edition
Tuesday, 20 September, 13:00–15:15, Delhi

As networks achieve increasing performance and scale, they push the boundaries of technology and face greater challenges to continued evolution. The IEEE International Network Generation Roadmap (INGR) is part of the IEEE Future Networks Initiative and was formed to roadmap wireless networks out to a 10 year horizon. Recently, the INGR was expanded to include optical networks. This symposium will present the first edition of the INGR Optics Roadmap, which include x-haul networks, high speed access and indoor networks, and AI in optical networks, among other areas. This symposium will highlighting key elements of the roadmap and look toward potential new areas in which to develop roadmaps. The broader optical networks community is invited to learn about and comment on the roadmap at this event.

Organisers Dan Kilper, Trinity College Dublin, Ireland
Shan Wey, Verizon, USA

Topics & Speakers
Overview of the INGR 2022 Edition
Dan Kilper, Trinity College Dublin, Ireland
X-Haul Networks
Reza Vaez-Ghaemi, Viavi, USA
Indoor Networks
Volker Jungnickel, Fraunhofer HHI, Germany
High Speed Access Networks
Hwan Seok Chung, ETRI, Korea
Future Roadmap Directions
Shan Wey, Verizon, USA
Submarine Networks
Lara Garrett, TE Subcom, USA
Quantum Networks
Rui Wang, University of Bristol, UK
Recent Advances in Submarine Systems: Submarine systems are evolving rapidly, with steadily increasing data capacity and fiber pair counts, and increasing levels of network connectivity complexity. These systems also provide important opportunities for the introduction of new technologies, because each new system is entirely new, without limitation from existing infrastructure. This symposium will invite key stakeholders to provide their view on the most important areas of technology evolution.

Organisers
Hidenori Takahashi, KDDI Research, Inc., Japan
Lara Garrett, SubCom, USA

Topics & Speakers
Innovations in 2Africa Submarine Cable Network
Herve Fervier, Meta, USA

Open Innovation in Japan for Next Generation Submarine Networks
Yoshishisa Inada, NEC, Japan

Fiber at a Crossroads: Which Path Do We Take?
Sergejs Makovejs, Corning, UK

Submarine Fiber Sensing and Monitoring Using Coherent Transceiver Technologies
Mikael Mazur, Nokia, USA

Flexibility of Undersea Systems Architecture and Design
Dmitriy Kovsh, SubCom, USA

Scaling Out Submarine Networks
Mattia Cantono, Google, USA

Automatic Optimization of Spectral Efficiency
Kim Roberts, Ciena, Canada

Subsea MCF Advances
Masaaki Hirano, Sumitomo, Japan

Innovation for Last Generation and Flexible Subsea Backhaul
Olivier Courtois, ASN, France

Fiber Options for Support of 1 to 5 Peta Bit Subsea Cables
Hans Damsgaard, OFS, Denmark

Integrated nonlinear photonics is a highly active research area. The investigations and study of nonlinear effects based on third-order nonlinearity, which is ubiquitous to all material platform through their third order susceptibility \( \chi^{(3)} \), is the most developed and now transitioning to proof-of-concept experimental applications. Unlike the widely accessible Kerr effect, second-order nonlinear effects are only intrinsic to non-centrosymmetric media. However, \( \chi^{(2)} \) nonlinearity is essential for the electro-optic effect and underpins various three-wave mixing parametric processes. With the recent maturing in fabrication of integrated waveguides based on materials exhibiting both \( \chi^{(2)} \) and \( \chi^{(3)} \) nonlinearities (SiC, LNOI, AlN…) new opportunities and physics might arise, but studies are still very recent.

This symposium focuses on the recent development in the design of integrated devices for leveraging both 2nd and 3rd order nonlinear effects. Different material platforms, approaches, potential and applications will be discussed.

Organiser
Camille-Sophie Brès, EPFL, Switzerland

Topical & Speakers
Lithium Niobate Integrated Photonics, from Highly Nonlinear to a Few Photons
Victor Brasc, Q.ANT, Germany

Few-Cycle Nonlinear Photonics: From Nanoscale Devices to Large-Scale Circuits
Alireza Marandi, California Institute of Technology, USA

Lithium Niobate Metasurfaces for Parametric Frequency Conversion
Frank Setzpfandt, Friedrich-Schiller University Jena, Germany

Photo-induced Harmonic and Comb Generation in Silicon Nitride Microresonators
Jianqi Hu, EPFL, Switzerland & Laboratoire Kastler Brossel, France

Nonlinear Photonics in Ultra-silicon-rich Nitride and Silicon Carbide Devices
Dawn Tan, Singapore University of Technology and Design, Singapore

Integrated quantum photonic circuits provide a viable route for the generation, manipulation, and detection of quantum states of light in miniaturized waveguide circuits. Implementation of these three operations in a single integrated platform is a crucial step toward a fully scalable approach to quantum photonic technologies. Diamond has emerged as a particularly promising material as it naturally combines a large transparency range for the fabrication of low-loss photonic circuits, and a variety of optically active defects for the realization of efficient single-photon emitters.

This symposium focuses on the opportunities and challenges of diamond-based integrated quantum photonic architectures. Implementations, physics and applications of diamond components for quantum technologies will be discussed.

Organisers
Wolfram Pernice, University of Münster, Germany
Alexander Kubanek, Ulm University, Germany

Topics & Speakers
Photonic Quantum Memories for Satellite Based Quantum Repeaters
Janik Wolters, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), TU Berlin, Germany

Diamond Spin Nanophotonics for Quantum Networks
Tim Schröder, Humboldt University Berlin, Germany

Integration of Spin-defects in SiC Nanostructures
Florian Kaiser, Universität Stuttgart, Germany

Quantum Networks, Computations and Simulations with Spins in Diamond
Tim Taminiau, TU Delft, Netherlands
We3G  • Quantum Communications – How Will Quantum Technology Revolutionize the Internet?
Wednesday, 21 September, 13:30–15:15, Kairo

Secure and robust optical networks are key for future interconnected societies. Quantum Technology will play a major role in that context as it will offer inherent hardware-based security, which will also withstand future security attacks based on Quantum Computers.

Major initiatives worldwide currently investigate prototypical Quantum Key Distribution (QKD) systems, which long-term will seamlessly include various different approaches including quantum repeaters, trusted nodes and satellite connections to also bridge long-haul distances.

This symposium shall investigate the state of the art and future directions of quantum communications, identifying technologies and challenges for enabling a future quantum Internet. It shall shed light on how and when such approaches may be ready for implementation into optical transmission systems and networks as well as what challenges still exist.

Organisers  Stephan Pachnicke, Kiel University, Germany
Michela Svaluto Moreolo, CTC, Spain
Paola Parolari, Politecnico di Milano, Italy

Topics & Speakers
DemoQuanDT: Deployment of a Long-haul QKD-link with Trusted Nodes
Oleg Nikiforov, Deutsche Telekom AG, Germany

Status and Perspectives of Satellite Quantum Communications: Toward a Fully Connected Quantum Network
Daniele Dequal, Agenzia Spaziale Italiana (ASI), Italy

Quantum Communication Networks: A Commercial Perspective
James Dynes, Toshiba, UK

Postquantum Cryptography and Standardization Efforts
Helmut Grießer, ADVA Optical Networking SE, Germany

QRNG and QKD Using Classical Hardware
Valerio Pruneri, ICFO, Spain

Functions Expected of the Quantum Internet and Roadmap in Japan
Mikio Fujiwara, NICT, Japan

We4G  • Photonic-Electronic Memristors for Neuromorphic Applications
Wednesday, 21 September, 15:45–17:30, Kairo

Today’s artificial intelligence (AI) performance has been significantly improved thanks to the CMOS technology and the high computational power brought by graphics processing units (GPUs) and application specific integrated circuits (ASICs). However, to keep up with this trend, a critical problem should be solved, the inherent high energy consumption induced by the continuous exchange of data between the memory and computing units, which are physically separated. This issue is known as the “von Neuman bottleneck”.

Several innovations in the field of information technology have shown promise in overcoming this fundamental limit. For example, recent developments of memristors, a class of two-terminal nano-devices with a variable resistance, enables the collocation of the computing and storing functionalities, thus circumventing the limitations of current von Neumann designs. On the other hand, progress in standard photonic circuits allows for high-bandwidth optical data communication. Ideally, a photonic-electronic platform is desired that can simultaneously take advantage of the high density and non-volatility of electronic memristors and of the high-speed communication capabilities provided by photonics/plasmonics components. In this symposium, we will discuss the challenges and opportunities of this platform.

The symposium is divided in three sessions: Session 1 will cover the theoretical aspects related to the understanding of the interplay between photonic, electronic, phononic and ionic interactions within memristors. Session 2 will focus on the materials needed for novel memristive material stacks. Session 3 will be related to the device engineering and novel opto-electronic applications.

Organiser  Alexandros Emboras, ETH Zurich, Switzerland

Topics & Speakers
Materials, Thicknesses and Capping Layer Selection for Improved Memristive Properties
Ilia Valov, Research Centre Jülich, Germany

Exploiting the Dynamics of Memristive Devices Based on the Valence Change Mechanism for Analog Computing
Stephan Menzel, Research Centre Jülich, Germany

Outperforming Machine Learning, Through Biological Models with Memristive Analogues
Timoleon Moraitis, Huawei Technologies – Zurich Research Center, Switzerland

Closing the Gap Between Devices, Circuits, and Algorithms Towards Brain-inspired Edge Computing
Melika Payvand, University of Zurich, Switzerland & ETH Zurich, Switzerland

A BaTiO3, Ferroelectric Multilayer Non-volatile Photonic Phase Shifter
Jacqueline Geler-Kremer, IBM Research–Europe, Switzerland

Picosecond Time-Scale Resistive Switching Monitored in Real-Time
Miklos Csontos, ETH Zurich, Switzerland

We1/2/3/4H  • 8th International Symposium for Optical Interconnect in Data Centres
Wednesday, 21 September, 08:30–17:30, Delhi

Data centres have continued to evolve dramatically over the past two years with hyperscale now the dominant form of data centre in the world, accelerating the convergence of 5G/6G and even quantum interconnect with traditional datacom into future data centres. This annual symposium continues to evolve accordingly to address these new disruptive technologies.

We address evolution of optical interconnect at the front panel with higher density SN/MDC type connectors, which increase optical channel density at the front panel dramatically over traditional MPO.

Co-Packaged Optics (CPO) and Near Packaged Optics (NPO) are driving the most dramatic industrial scale photonic integration exercise ever known, while advances in the underlying Photonic Integrated Circuit (PIC) platforms introduce exciting new materials to further reduce power consumption on optical operations and advances in thermo-plastics are opening the door to solder-reflow resistant complex, low-cost micro-optical components for higher temperature environments.

Finally, the last two years have seen the introduction of quantum security products, such as quantum random number generators, of quantum networks, quantum computers and
machine learning techniques. Quantum communication will become an indispensable means of securing any communication between data centres and the outside world while “Quantum as a Service” (QaaS) schemes will increasingly allow access to quantum computer facilities within the data centre. In parallel, Machine Learning techniques are expected to facilitate signal conditioning, routing and security functionalities by replacing conventional digital processing circuitry and offering a higher energy efficiency framework.

**Organisers**
- Tolga Tekin, Fraunhofer IZM, Germany
- Nikos Pleros, Aristotle University of Thessaloniki, Greece
- Richard Pitwon, Resolute Photonics, Ireland
- Dimitrios Apostolopoulos, National Technical University of Athens, Greece
- Paraskevas Bakopoulos, NVIDIA, NVIDIA, Greece

**Topics & Speakers**

**Trends in Next-generation Data Center Interconnects**
Jörg-Peter Elbers, ADVA, Germany

**Scaling Programmable Energy Efficient Photonic Interconnects Beyond Tbps**
Ioannis Tomkos & Moshe Nazarathy, University of Patras, Greece & Technion, Israel

**Title: to be announced**
Elad Mentovich, NVIDIA, Israel

**Simplification of Intra Data Center Architectures with Point-to-Multipoint Coherent Transceivers**
Antonio Napoli, Infineon, Germany

**Enabling Technologies for Optical Switching in Data Centers**
Maxim Kuschnerov, Huawei Research Center, Germany

**Nanoseconds Photonic Networks for Computing with Shared Memory**
Nicola Calabretta, Eindhoven University of Technology, Netherlands

**Optical Switching and Networking for Distributed Deep Learning Systems**
George Zervas, University College London, UK

**How to Build a Commercial Quantum Network**
Andrew Lord, BT, UK

**Role of Optical Interconnect in Building Scalable and Multi-tenant Quantum Computing as a Quantum Data Centre**
Reza Nejabati, University of Bristol, UK

**Silicon Photonics Technology for Future Large-scale Deployment of Quantum Communication Links**
Ségolène Olivier, CEA-LETI, France

**Quantum Noise Limited Ultra-low Energy Links for Data Centers**
Darko Zibar, Technical University of Denmark, Denmark

**Optical Interconnects for Cryogenic Applications**
Paolo Pintus, University of California Santa Barbara, USA

**Innovations in Optical Interconnect for High Performance Data Center Systems**
Bernard Lee, Senko Advanced Components, Malaysia

**Silicon Photonics for Data Center Interconnects and Security Applications**
Miltiadis Moralis-Pegios, Aristotle University of Thessaloniki, Greece

**Novel Thermoplastic Resins for Optical Interconnects**
Gabrie Hoogland, SABIC, Netherlands

**Intel’s Participation in DARPA CHIPS, PIPES and Space-BACN Programs - Scaling New Benchmarks in Photonic Performance and Integration**
Conor O’Keeffe, Intel, Ireland

**CPO for Radio Systems**
Stephane Lessard, Ericsson, Italy

**Automated Assembly Solutions as Key for Mass Manufacturing of High-speed Photonic Transceivers**
Moritz Seyfried, ficonTEC, Germany

**Near Package Optics (NPO) Module for PCIe Gen 5 Interconnect**
Tomoyuki Akahoshi, Kyocera, Japan

**Toward Next-generation Data Center and HPC Networks with Co-packaged Optics**
Pavllos Maniotis, IBM T. J. Watson Research Center, USA

**Faster, Higher, Stronger: Co-packaged Optics**
Marian Bogdan Sirbu, Fraunhofer IZM, Germany

**Photonic Connectivity for Accelerating AI Computing**
Keren Bergman, Columbia University, USA

**Programmable Integrated Photonics for Edge and Cloud Data Centers: Application and Functionality Scenarios**
Jose Capmany, iPRONICS, Spain

**Photonic Crystal Surface Emitting Lasers (PCSELs) at Multiple Wavelengths for High Bandwidth Data Communications**
Calum Hill, Vector Photonics, UK

**Title: to be announced**
Lars Zimmermann, IHP, Germany

**A Pockels-boost for PICs – How Communication Chips Will Reach New Performance Levels**
Stefan Abel, Lumiphase, Switzerland

**Unrolling the New AI Era – Photon by Photon**
Angelina Totović, Celestial AI, USA & Aristotle University of Thessaloniki, Greece

**Plasmonics – Key Technology to the Terabaud Age**
Jürg Leuthold & David Moor, ETH Zurich, Switzerland

**Th1/2B • Free Space Optical Communication for Terrestrial & Space Applications**

**Free Space Optical Communication (FSO) has become an impressive momentum over the past years. For a long time, FSO applications for space borne systems have been deployed as niche and at significant cost. Global efforts to make reliable use of novel technologies and building blocks developed for non-space applications («COTS») now pay off and the deployment of FSO for a large range of space-based use cases has become reality.**

In parallel to the space domain, FSO has become an alternate to other classical communication means and will further grow in importance helping to overcome bottlenecks in RF arising from the ever-growing capacity needs of mankind.

This Symposium is intended to give a updated overview on the status on development and deployment of FSO in the various scenario, such as Space based systems, mid and short range FSO in atmosphere but will also address enabling technologies to support specific needs for FSO systems.

**Organiser**
Reto Muff, Thales Alenia Space, Switzerland
a wide bandwidth and interaction with atmospheric constituents and consequent narrow beams, operation across an excellent sensing medium, thanks to the modest size of the 

On the other hand, mm-wave bands have also proved to be (sub-)THz regime. 

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projected to the future, is already studying the potential to 

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spectrum for high-speed wireless communication. In addition, 

The increasing bandwidth requirement of new wireless ap 

lications has led to standardization of the millimeter wave 

spectrum for high-speed wireless communication. In addition, 

in the newest generation of cell phone and 5G networks, such 

a frequency regime allows smaller frequency reuse distances 

and hardware miniaturization. Scientific research then, always 

projected to the future, is already studying the potential to 

extend the carrier frequency of wireless systems up to the 

(sub-)THz regime. 

On the other hand, mm-wave bands have also proved to be an excellent sensing medium, thanks to the modest size of antennas and consequent narrow beams, operation across a wide bandwidth and interaction with atmospheric constituents. Going up to Terahertz then, opens up countless new applications in biology, medicine, security, cultural heritage and beyond.

In both these macro-sectors – communication and sensing – photonics becomes the answer to the challenges related to the generation and distribution of mm-wave signals.

This symposium will review and discuss the recent progress and future challenges of mm-wave communication and radar systems, focusing on how photonics technologies may impact the usage of mm-wave bands, as well as the potentialities and current limits of the sub-THz and THz regimes, in these as in other applications.

Organisers
Antonella Bogoni, Sant’Anna School of Advanced Studies, Italy
Thomas R. Clark, JHU Applied Physics Laboratory, USA
Cristina Benea, EPFL, Switzerland
Antonio Malacarne, CNIT, Italy

Topics & Speakers
Perspectives of Photonics-based Sub-THz Generation for Wireless Communications
Maurizio Burla, TU Berlin, Germany
Precise and High-speed Optical Modulation for Millimeter-wave and THz-wave Generation
Tetsuya Kawanishi, Waseda University, Japan
Observations from Using mm-Wave Radars in Hospitals & Long-Term Care Homes
George Shaker, University of Waterloo, Canada
Progress and Prospects of High-average Power THz Pulsed Sources
Claire Saraceno, Ruhr University Bochum, Germany

Th2H • Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO2)
Thursday, 22 September, 10:45–12:30, Delhi

The model of photonic devices has been evolving from standard packaging to photonic integrated circuits with more efficient and low-cost coupling solutions, compatible for ultra-dense integration. Multiple developments have been done on photonic integrated circuits, either fully on InP platforms mainly for active devices (lasers, high-speed modulators, photodiodes, …), or with Silicon Photonics (passive devices, high-speed modulators, photodiodes, …). But to make the best of both platforms in terms of performances and economic model, many laboratories or companies develop hybrid integration of III-V materials and Silicon-based devices (with Si, SiN, or SiO2 waveguides).

This workshop will focus on the solutions for this hybrid integration, and will present the different technologies to couple light from III-V material to Si-based waveguides. Firstly, heterogeneous integration where III-V lays directly on top of Si-based waveguides with evanescent coupling. Secondly hybrid integration, where the III-V device is butt-jointed to Si-based waveguides, with various alignment techniques and waveguiding approaches. Thirdly, it will present emerging technologies still in development, their challenges and potential, such as transfer printing or direct growth in Si.

The comparison will not only be on the technical / performances point of view, but as well on the business aspects, by analysing the business model, versatility and compatibility with multiple suppliers or external foundries, process tolerance to improve yield and costs. Presenters will explain what drove their choices, what are their main applications today and how they foresee future evolutions.

Organisers
Hélène Debrégeas, Almae Technologies, France
Lucas Soldano, POET Technologies, USA

Topics & Speakers
Hybrid Integration of III-V Materials with Silicon for High-volume and High-reliability Lasers and Optical Amplifiers
Scott Schube, Intel, USA

An Overview on Thick-SOI Silicon Photonic Platforms and Integration Roadmap at VTT
Giovanni Delrosso, VTT, Finland

Hybrid Integration Platform for Co-Packaged Photonics Using POET’s CMOS Based Optical Interposer
Suresh Venkatesan, POET Technologies, USA

Hybrid integration of III-V semiconductors on silicon
Dries Van Thourhout, Ghent University - IMEC, Belgium
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Switzerland, the focus is on products for inter-satellite links and optical communication payloads and, particularly in space. Nowadays, Thales Alenia Space is active in developing new observational approaches and detection algorithms. He participated to numerous documentaries, movies, articles, and presentations they announced the first discovery of a giant planet orbiting another star, outside our solar system. More recently, he is directing his activity to the detection of Earth-like planets and universal life. In the course of his career, he developed astronomical equipment, new observational approaches and detection algorithms. He participated to numerous documentaries, movies, articles, and TV and radio interviews to share excitement and promote interest for science in general and in particular about exoplanets and life in the universe. Didier Queloz was at the origin of the “exoplanet revolution” in astrophysics when in 1995 during his PhD with his supervisor they announced the first discovery of a giant planet orbiting another star, outside the solar system. This seminal discovery has spawned a revolution in astronomy and kickstarted the field of exoplanet research. Over the next 25 years, Didier Queloz scientific contributions have been essential towards advancing detection and measurement capabilities of exoplanet systems with the goal to retrieve information on their physical structure and to better understand their formation and evolution by comparison with our solar system. Didier Queloz, Full Professor, ETH Zurich, Switzerland The Exoplanet Revolution Public Nobel Prize Lecture Sunday, 18 September, 18:00–19:00, San Francisco Didier Queloz was at the origin of the “exoplanet revolution” in astrophysics when in 1995 during his PhD with his supervisor they announced the first discovery of a giant planet orbiting another star, outside our solar system. This seminal discovery has spawned a revolution in astronomy and kickstarted the field of exoplanet research. Over the next 25 years, Didier Queloz scientific contributions have been essential towards advancing detection and measurement capabilities of exoplanet systems with the goal to retrieve information on their physical structure and to better understand their formation and evolution by comparison with our solar system. More recently, he is directing his activity to the detection of Earth-like planets and universal life. In the course of his career, he developed astronomical equipment, new observational approaches and detection algorithms. He participated to numerous documentaries, movies, articles, and TV and radio interviews to share excitement and promote interest for science in general and in particular about exoplanets and life in the universe.

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David F. Welch, Chief Innovation Officer, Infinera, USA Scenarios of future innovations in the network Monday, 19 September, 09:50–10:20, San Francisco “Innovation has been the primary enabler for scale and cost in the network; what are the innovations of tomorrow?”

David F. Welch, Ph.D. co-founded Infinera in 2001, and serves as Chief Innovation Officer and on the Board of Directors. He holds over 130 patents in optical transmission technologies, and has authored over 300 technical publications. In recognition of his technical contributions to the optical industry, he was awarded the OSA’s Adolph Lomb Medal, Joseph Fraunhofer Award and John Tyndall Award, the IEEE’s JJ Thompson Medal for Achievement in Electronics, and the IEEE Ernst Weber Managerial Leadership Award. A Fellow of the OSA and the IEEE, he was elected to the National Academy of Engineering in 2016. Dr. Welch holds a B.S. in Electrical Engineering from the University of Delaware and a Ph.D. in Electrical Engineering from Cornell University.

Elisabetta Rugi Grond, Chief Executive Officer, Thales Alenia Space, Switzerland Optical communications in space: challenges and opportunities Monday, 19 September, 09:20–09:50, San Francisco

Elisabetta Rugi Grond has been working in the development of instruments for Science and Earth Observation and has been focusing on optical communication since the mid ’90. In 2016, she became CEO of Thales Alenia Space in Switzerland after serving as General Manager of Optoelectronics and Instruments Business Unit at RUAG Space. Nowadays, Thales Alenia Space is active in developing optical communication payloads and, particularly in Switzerland, the focus is on products for inter-satellite links and direct to Earth applications. Elisabetta Rugi Grond is holding a Master’s Degree in Aerospace Engineering from University of Pisa and is, amongst other appointments, member of the Swiss Federal Commission for Space Affairs, Conseillere du commerce extérieur de la France and industry representative in the steering committee of Swiss Space Innovation.

Christoph Glingener, Chief Technology Officer, ADVA, Germany Never say never again Monday, 19 September, 11:00–11:30, San Francisco

Dr. Christoph Glingener is a networking industry pioneer and spend most of his career on innovative optical connectivity technologies and has more than 150 publications and 130 patents in optical transmission technologies. As Chief Innovation Officer and on the Board of Directors, he is responsible for steering ADVA’s product strategy, building a unified development operations team and propelling its leadership in optical networking, edge cloud and synchronization. Before joining ADVA, Dr. Christoph Glingener held senior positions in academic and corporate organizations, including Marconi Communications (now Ericsson) and Siemens Communications (now Infinera). He holds a Diploma and a Ph.D. in Electrical Engineering from the Technical University of Dortmund, Germany.

Mark G. Thompson, Chief Technologist, PsiQuantum, USA Path to a useful quantum computer Monday, 19 September, 11:30–12:00, San Francisco

Mark Thompson is co-founder and Chief Technologist of PsiQuantum - a quantum computing company pioneering the development of large-scale fault tolerant quantum computers. Thompson has over 20 years’ experience in the fields of integrated photonics and quantum technologies, having previously worked at Corning, Bookham Technology and Toshiba, and held research fellowships at the University of Cambridge and Professorship at the University of Bristol. In 2013 at the University of Bristol, he established the world’s 1st PhD training center in Quantum Engineering (OECDT), and in 2016 the 1st quantum technology incubator and entrepreneurship training center (QTEC) dedicated solely to supporting quantum-technology startups. He has been awarded prestigious UK and European fellowships and prizes (including UK- EPSRC fellowship and EU-ERC starter grant), has more than 150 publications and patents, and founded two startup companies in quantum technologies.
SC1 – Novel Fibres, Fibre Devices & Amplifiers
Siddharth Ramachandran, Boston University, USA
Spatially, Vectorially and Topologically Complex Light in Fibers: Implications & Applications
We3A.1 – Wednesday, 21 September, 13:30–14:30, Samarkand + Osaka

Abstract: Multimode fibers support light transmission in a variety of spatially, vectorially and topologically complex states. Here, we describe how this recently accessible degree of freedom for encoding information in a photon has impacted applications as disparate as quantum communications, classical communications, bio-imaging, and directed-energy lasers.

Biography: Siddharth Ramachandran (FSPIE, FOSA, FIEEE) started his career at Bell Labs, and after a decade in industrial research labs, returned to academia, to Boston University, where he is currently a Distinguished Professor of Engineering. His research interests include the study and applications of linear, nonlinear and quantum properties of high-dimensional light.

SC2 – Photonic Devices & Technologies
Goran Mashanovich, University of Southampton, UK
Silicon and Germanium Mid-IR Devices and Circuits
Tu1E.1 – Tuesday, 20 September, 08:30–09:30, Boston

Abstract: Mid-infrared integrated photonics has become a very attractive research area due to a host of important applications. Silicon and germanium offer low-cost manufacturing of photonic circuits. In this tutorial I will cover recent progress in passive and active silicon and germanium mid-IR devices and circuits.

Biography: Professor Goran Mashanovich is head of the Mid-IR Silicon Photonics Group at the Optoelectronics Research Centre, University of Southampton, UK. He received PhD in Silicon Photonics from the University of Surrey, UK and Dipl. Ing. and MSc in Optoelectronics from the University of Belgrade, Serbia, where he is a visiting professor.

SC3 – Photonic Integrated Circuits, Assemblies & Packaging
Toshihiko Baba, Yokohama National University, Japan
FMCW LiDAR Incorporating Slow-Light Grating Beam Scanners
Th1F.1 – Thursday, 22 September, 08:30–09:30, Shanghai

Abstract: Slow-light grating based on photonic crystal waveguides, fabricated by standard silicon photonics process, allows electrically driven completely nonmechanical 2D beam scanning with high resolution and wide field of view. It is incorporated in an integrated FMCW LiDAR chip and real time LiDAR operation is obtained.

Biography: Dr. Toshihiko Baba received the PhD degree from Yokohama National University in 1990 and became a full professor of this university in 2005. He has studied photonic crystals, Si photonics, slow light, nanolaser, biosensing, high-speed modulator, LiDAR, topological photonics, etc., for more than 30 years. He is a fellow of IEEE and OPTICA.

SC4 – Techniques for Digitally Enhancing Optical Communication
Christian Häger, Chalmers Tekniska Högskola, Sweden
We2C.1 – Wednesday, 21 September, 10:45–11:45, Sydney

Abstract: This tutorial will review communication autoencoders where the main idea is to replace handheld transmitter and receiver algorithms with neural networks and jointly optimize them in an end-to-end fashion. We discuss several applications to optical systems including training with multiple users and channel capacity estimation.

Biography: Christian Häger is an Assistant Professor in the Department of Electrical Engineering at Chalmers University of Technology, Sweden. His research interests lie at the intersection of communication systems, machine learning, and signal processing.

SC5 – Theory of Optical Communications
Joseph M. Kahn, Stanford University, USA
Modal Multiplexing and Atmospheric Turbulence Mitigation in Free-Space Optical Communications
Tu4D.1 – Tuesday, 20 September, 15:45–16:45, Rio

Abstract: Spatial-mode multiplexing (SMM) increases freespace optical link capacity, but is impaired by atmospheric turbulence. We derive the optimal modes for SMM in turbulence, showing they achieve higher capacity than other mode sets. We review methods for modal (de)multiplexing and MIMO signal processing in SMM links.

Biography: Joseph M. Kahn is Professor of Electrical Engineering at Stanford University. Achievements include: first synchronous (coherent) detection in fiber optics (1989); first probabilistic shaping in optical communications (1999); founding StrataLight Communications, leader in first-generation phase-modulated fiber transmission systems (2000); first electronic compensation of fiber Kerr nonlinearity (2002), leading to digital backpropagation (2008).

SC6 – Optical Transmission Systems
Elizabeth Rivera Hartling, Meta Platforms Inc, USA
Subsea Open Cables Designs, challenges and an outlook for the future
We1D.1 – Wednesday, 21 September, 08:30–09:30, Rio

Abstract: Subsea Open Cable Designs have become the industry norm, and collaborative efforts to standardize GSNT has provided foundational tools for
broad industry adoption. Technology advancements in SDM continue to increase cable capacity potential, and additional forward-looking developments are charting a path towards Petabit cables.

**Biography:** Elizabeth Rivera Hartling is a Global Subsea Optical Network Architect at Meta, focused on optimizing Meta Subsea Open Cable designs, to build a scalable, high capacity, cost-effective optical network. Elizabeth has been designing and executing coherent solutions on subsea cables since 2008.

**SC7 – Core & Metro Networks**

Qunbi Zhuge, Shanghai Jiao Tong University, China

**AI-driven Digital Twin for Optical Networks**

Mo3A.1 – Monday, 19 September, 13:30–14:30; Samarkand + Osaka

**Abstract:** Building digital twin for self-driving optical networks requires physical layer modeling, impairment monitoring and adaptive learning technologies. This tutorial will review the recent advances on these aspects, focusing on the adoption of AI algorithms and methodologies to enable full-life cycle assessment of network status.

**Biography:** Qunbi Zhuge is an Associate Professor at Shanghai Jiao Tong University in China. His current research interests include wideband optical transmission, intelligent optical networks and optical-wireless convergence. He has published 180+ papers, and served as an Associate Editor of Optics Express and a Subcommittee Chair of OFC 2019. He is an IEEE/OSA senior member.

**SC8 – Access, Indoor & Short-Reach for Data Centres and Mobile Networks**

Mark M. Filer, Google Inc, USA

**The Role of Standardization, Interoperability, and Open Ecosystems in Hyperscale Data Centers**

Th2D.1 – Thursday, 22 September, 10:45–11:45, Rio

**Abstract:** This tutorial highlights recent efforts toward enabling hyperscale data center networks which employ standardized, interoperable, and/or open hardware and software.

**Biography:** Mark works at Google as Optical Network Architect, focusing on campus, metro DCI, and wide-area network optical solutions, and next-gen datacenter network architectures. Prior to Google, he held positions at Microsoft, AWS, and ADVA Optical Networking. In addition, Mark currently serves on the OIF Board of Directors as Vice President.

**SC9 – Photonics for RF & Free-Space Optics Applications**

Christoph Marquardt, Max-Planck-Institut für die Physik des Lichts, Germany

**Satellite-based Quantum Key Distribution**

We4F.1 – Wednesday, 21 September, 15:45–16:45, Shanghai

**Abstract:** Currently deployed cryptographic methods are at risk by future attacks e.g. by quantum computer algorithms. Satellite-based quantum key distribution offers worldwide long-term security for critical infrastructure and secure communication. I will review concepts and discuss current activities.

**Biography:** Christoph Marquardt is heading the chair of optical quantum technologies at the Friedrich-Alexander-Universität Erlangen-Nürnberg and is leading the quantum information processing group at the Max Planck Institute for the Science of Light. His research covers a broad range of quantum optics and quantum information experiments, from nonlinear photonics to satellite-based quantum key distribution. He is active in several EU and national quantum communication research projects and is taking care of the architecture of the German BMBF QuNet initiative.

**SC10 – Architecture, Control & Management of Optical Networks**

Emmanouel Varvarigos, National Technical University of Athens, Greece

**Resource Orchestration in Support of Edge Computing in Optical Networks**

Mo4B.1 – Monday, 19 September, 15:45–16:45, Singapore

**Abstract:** Not available

**Biography:** Not available

**CLEO®/Europe Focus Meeting**

Michal Lipson, Columbia University, USA

**The State of the Art and Challenges of Silicon Photonics Today**

Tu3G.2 – Tuesday, 20 September, 14:00–15:00, Kairo

**Abstract:** We are now experiencing a revolution in optical technologies, where one can print and control massive optical circuits, on a microelectronic chip. This revolution is enabling a whole range of applications that are in need for scalable optical technologies and its opening the door to areas that only a decade ago were unimaginable.

**Biography:** Michal Lipson is the Eugene Higgins Professor at Columbia University. Her research focus is on Nanophotonics and includes the investigation of novel phenomena, and the development of novel devices and applications. She pioneered critical building blocks in the field of Silicon Photonics, which today is recognized as one of the most promising directions for solving the major bottlenecks in microelectronics. She is the inventor of over 45 issued patents and has co-authored more than 250 scientific publications.
Invited Speakers

**SC1 – Novel Fibres, Fibre Devices & Amplifiers**

Pierre Sillard, Prysmian Group, France  
*Single-Mode Fibers with Reduced Cladding and/or Coating Diameters*  
Tu3A.1 – Tuesday, 20 September, 13:30–14:00, Samarkand + Osaka

Russell Ellis, Lumenisity Ltd., UK  
*Commercial Opportunities and Future Roadmap for Hollow Core Fibres*  
Tu3A.5 – Tuesday, 20 September, 14:45–15:15, Samarkand + Osaka

Miguel Gonzalez-Herraez, Universidad de Alcalá, Spain  
*Time-expansion in Distributed Fibre Optic Sensing*  
Tu4A.1 – Tuesday, 20 September, 15:45–16:15, Samarkand + Osaka

Natalie V. Wheeler, University of Southampton, UK  
*Tweaking the Optical Properties of a Hollow Core Optical Fibre by Changing Core and Cladding Gas Pressures*  
Tu4A.6 – Tuesday, 20 September, 17:15–17:45, Samarkand + Osaka

Xinglin Zeng, Max-Planck-Institute, Germany  
*Stimulated Brillouin Scattering in Chiral Photonic Crystal Fibre*  
We4A.3 – Wednesday, 21 September, 16:15–16:45, Samarkand + Osaka

**SC2 – Photonic Devices & Technologies**

Sylvie Menezo, SCINTIL Photonics, France  
*Fully Integrated Silicon Photonic Circuit Technology with Monolithic III-V/Si Lasers and Amplifiers Integrated at the Backside of Advanced Silicon Photonics Wafers*  
Tu3E.1 – Tuesday, 20 September, 13:30–14:00, Boston

Wolfgang Heni, Polariton Technologies Ltd, Switzerland  
*Plasmonic PICs — Terabit Modulation on the Micrometer Scale*  
Tu4E.3 – Tuesday, 20 September, 16:15–16:45, Boston

Mircea D. Guina, Tampere University, Finland  
*Hybrid Integration of GaSb Optoelectronics with Thick-SOI and SiN PIC Platforms*  
We1E.1 – Wednesday, 21 September, 08:30–09:00, Boston

Thomas Ferreira de Lima, NEC Laboratories America, USA  
*Photonic Neural Networks for Analog-Digital Processing*  
We1E.5 – Wednesday, 21 September, 09:45–10:15, Boston

Sangyoon Han, DGIST, Korea  
*Silicon Photonic MEMS for Programmable Photonics*  
We2E.6 – Wednesday, 21 September, 12:00–12:30, Boston

Xi Xiao, China Information and Communication Technologies Group Corporation (CICT), China  
*High Baudrate Silicon Photonics for the Next-generation Optical Communication*  
We4E.1 – Wednesday, 21 September, 15:45–16:15, Boston

Haisheng Rong, Intel Corporation, USA  
*Integrated Silicon Photonic Transceiver Chips for High Bandwidth Density and Energy-efficient Optical I/O*  
Th1E.1 – Thursday, 22 September, 08:30–09:00, Boston

Johann Troles, Université de Rennes I, France  
*3D Printed Chalcogenide Fiber*  
Th1A.3 – Thursday, 22 September, 09:30–10:00, Samarkand + Osaka

**SC3 – Photonic Integrated Circuits, Assemblies & Packaging**

Yoshihiro Ogiso, Nihon Denshin Denwa Kabushiki Kaisha, NTT Photonics Laboratories, Japan  
*High-Bandwidth InP MZ/IQ Modulator PIC Ready for Practical Use*  
Mo3F.3 – Monday, 19 September, 14:00–14:30, Shanghai

Samuel Palermo, Texas A&M University, USA  
*CMOS Transceiver Circuits for Energy Efficient Silicon Photonic Interconnects*  
Mo4F.3 – Monday, 19 September, 16:15–16:45, Shanghai

Karl Muth, OSD, Broadcom Ltd, USA  
*Key Technology Enablers for Co-packaged Optics*  
Tu1F.1 – Tuesday, 20 September, 08:30–09:00, Shanghai

Benjamin G. Lee, NVIDIA Corporation, USA  
*Photonic Circuits for Accelerated Computing Systems*  
Tu1F.4 – Tuesday, 20 September, 09:30–10:00, Shanghai

Bhavin J. Shastri, Queen’s University, Canada  
*Silicon Photonics for Machine Learning: Training and Inference*  
Tu4G.1 – Tuesday, 20 September, 15:45–16:15, Kairo

Chaoran Huang, Chinese University of Hong Kong, Hong Kong  
*WDM Based Photonic Neural Network for Multi-channel Optical Fiber Communications*  
Tu4G.4 – Tuesday, 20 September, 16:45–17:15, Kairo

**SC4 – Techniques for Digitally Enhancing Optical Communication**

Masataka Nakazawa, Tohoku University, Japan  
*GAWBS Noise in Digital Coherent Transmission*  
We1C.1 – Wednesday, 21 September, 08:30–09:00, Sydney

Junho Cho, Infinera Corp, Canada  
*Probabilistic Constellation Shaping and Subcarrier Multiplexing for Nonlinear Fiber Channels*  
We3C.4 – Wednesday, 21 September, 14:15–14:45, Sydney
SC6 – Optical Transmission Systems

**Oleg V. Sinkin, SubCom, USA**

**Strategies and Challenges in Designing Undersea Optical Links**

Tu1D.3 – Wednesday, 21 September, 09:45–10:15, Rio

**Hiroyuki Taniguchi, NTT Network Innovation Laboratories, Japan**

**Advanced O-band Transmission Using Maximum Likelihood Sequence Estimation**

We2D.1 – Wednesday, 21 September, 10:45–11:15, Rio

**Robert Maher, Infinera Corporation, USA**

**Real-Time 1.6Tb/s Super-Channel Transmission using a Vertically Integrated 100 Gbd PCS-64QAM Coherent MODEM**

We3D.1 – Wednesday, 21 September, 13:30–14:00, Rio

**Takeo Sasai, NTT Corporation, Japan**

**Digital Longitudinal Monitoring of Optical Transmission Link**

Th1D.1 – Thursday, 22 September, 08:30–09:00, Rio

**Hitoshi Takeshita, Advanced Network Research Laboratories, Nihon Denki Kabushiki Kaisha, Japan**

**MCF in Cable and Transmission Trials**

Th1D.5 – Thursday, 22 September, 09:45–10:15, Rio

SC7 – Core & Metro Networks

**Matteo Lonardi, Nokia Bell Labs, Italy**

**The Glass of Machine Learning for QoT Estimation Is Half Full**

Mo3A.2 – Monday, 19 September, 14:30–15:00, Samarkand + Osaka

**Valey Kamalov, Google LLC, USA**

**Optical Fiber Networks for Environmental Sensing**

Mo4A.3 – Monday, 19 September, 16:15–16:45, Samarkand + Osaka

**Amirhossein Ghazisaeidi, Nokia Bell Labs, France**

**High Secret Key Rate CV-QKD Systems Leveraged by Advanced Coherent Detection**

Tu4D.2 – Tuesday, 20 September, 16:45–17:15, Rio

**Pierpaolo Boffi, Politecnico di Milano, Italy**

**Sensing Applications in Deployed Telecommunication Fiber Infrastructures**

Mo4A.4 – Monday, 19 September, 16:45–17:15, Samarkand + Osaka

**Di Che, Nokia Bell Labs, USA**

**Is It Meaningful to Pursue Higher Symbol Rate beyond Bandwidth Constraint for Short-Reach Interconnects?**

Tu1A.3 – Tuesday, 20 September, 09:00–09:30, Samarkand + Osaka

**André Richter, VPIphotonics, Germany**

**Challenges in Modeling Wideband Transmission Systems**

We1A.1 – Wednesday, 21 September, 08:30–09:00, Samarkand + Osaka

**Paul Wright, British Telecom, UK**

**Recent Trials in ZR and XR Pluggable Technologies**

We2A.4 – Wednesday, 21 September, 11:30–12:00, Samarkand + Osaka

**Harry Zervos, National Technical University of Athens, Greece**

**The QAMeleon Ecosystem: SDN-enabled High-speed Transceivers and Photonic Switches for the Next Generation of DCI and Metro Networks**

We2A.5 – Wednesday, 21 September, 12:00–12:30, Samarkand + Osaka
Annachiara Pagano, Telecom Italia, Italy
Is There Room for Quantum Photons in my Access Network?
Tu1C.4 – Tuesday, 20 September, 09:30–10:00, Sydney
Keren Bergman, Columbia University, USA
Peta-scale Embedded Photonics for High Performance Computing
Tu3C.1 – Tuesday, 20 September, 13:30–14:00, Sydney
Christopher R. Cole, II-VI Incorporated, USA
Datatransceivers in the Next Decade
Tu3C.2 – Tuesday, 20 September, 14:00–14:30, Sydney
Amikumar Mahadevan, Nokia Bell Labs, USA
Digital Signal Processing for Next Generation PONs
Tu4C.1 – Tuesday, 20 September, 15:45–16:15, Sydney

SC9 – Photonics for RF & Free-Space Optics Applications
Leontios Stampoulidis, G&H, Greece
New Generation Space Photonics Components and Sub-systems for High Data Rate Intra and Inter-satellite Optical Communications
Tu3F.1 – Tuesday, 20 September, 13:30–14:00, Shanghai
Dimitar R. Kolev, National Inst of Information & Comm Tech, Japan
Latest Developments in the Field of Optical Communications for Small Satellites and Beyond
Tu4F.3 – Tuesday, 20 September, 16:15–16:45, Shanghai
Jonathan Doylend, Intel Corporation, USA
State of the Art in Silicon Photonics Integrated Circuits for LIDAR
We1F.4 – Wednesday, 21 September, 09:15–09:45, Shanghai
Jianjun Yu, Fudan University, China
Broadband Photon-assisted Terahertz Sensing and Communication
We2F.1 – Wednesday, 21 September, 10:45–11:15, Shanghai
Nan Chi, Fudan University, China
Visible Light Communication Toward 6G: Key Technologies and Future Perspective
We3F.6 – Wednesday, 21 September, 14:45–15:15, Shanghai

Sébastien Bigo, Nokia Bell Labs, France
How Far Could we Stretch the Capacity of Optical Satellite Communications?
We4F.2 – Wednesday, 21 September, 16:45–17:15, Shanghai

SC10 – Architecture, Control & Management of Optical Networks
Jelena Pesic, Nokia Bell Labs, France
New Trends in Low Margin Optical Networks
Mo3B.1 – Monday, 19 September, 13:30–14:00, Singapore
S. J. Ben Yoo, University of California Davis, USA
New Trends in Photonic Switching and Optical Network Architecture for Data Centre and Computing
Tu1B.1 – Tuesday, 20 September, 08:30–09:00, Singapore
Jun Terada, NTT Access Service Systems Laboratories, Japan
Time Sensitive Networking for 5G and Beyond
Tu1B.5 – Tuesday, 20 September, 09:45–10:15, Singapore
Marija Furdek, Chalmers Tekniska Högskola, Sweden
Physical Layer Security Management in Optical Networks
Tu3B.1 – Tuesday, 20 September, 13:30–14:00, Singapore
Paolo Monti, Chalmers Tekniska Högskola, Sweden
Fiber vs. Microwave-based 5G Transport: a Total Cost of Ownership Analysis
We1B.5 – Wednesday, 21 September, 09:30–10:00, Singapore
Arturo Mayoral, Telecom Infra Project, USA
Unified SDN Control and Management of the Disaggregated Multi-vendor IP over Open Optical Network
We2B.1 – Wednesday, 21 September, 10:45–11:15, Singapore
Jan Kundrát, CESNET, Czechia
GNPy: Lessons Learned and Future Plans
We3B.6 – Wednesday, 21 September, 14:45–15:15, Singapore
Glenn Wellbrock, Verizon Inc, USA
Distributed Fiber Sensing Applications
We4B.1 – Wednesday, 21 September, 15:45–16:15, Singapore

CLEO®/Europe Focus Meeting
Alejandro Rodriguez, Princeton University, USA
Photonic Optimization: Approaching the Limits of Light Control
Mo3G.1 – Monday, 19 September, 13:30–14:00, Kairo
Mercedeh Khajavikhan, University of Southern California, USA
Topological Photonic Devices
Mo3G.5 – Monday, 19 September, 14:45–15:15, Kairo
Martin Wegener, Karlsruher Institut für Technologie, Germany
3D Laser Printing Based on Two-step Absorption
Mo4G.1 – Monday, 19 September, 15:45–16:15, Kairo
Maria Tchernycheva, IEF, France
Microwave-optical Transduction with Integrated Gallium Phosphide Devices
Th1G.6 – Thursday, 22 September, 09:45–10:15, Kairo
Mercedes de La Torre, Center for Nanotechnology Research, USA
Molecular Optomechanical Springs for Infrared Metasurface Detectors
Tu1G.4 – Tuesday, 20 September, 09:30–10:00, Kairo
Jan van Schoot, ASML Netherlands B.V., Netherlands
EUV Lithography: A Role in Photonics? A Deeper Insight in the EUV Exposure Tools
Tu3G.1 – Tuesday, 20 September, 13:30–14:00, Kairo
Paul Seidler, IBM Research GmbH, Switzerland
Microwave-optical Transduction with Integrated Gallium Phosphide Devices
Th2G.3 – Thursday, 22 September, 11:15–11:45, Kairo
Thilo Stöferle, IBM Research GmbH, Switzerland
Cooperative Quantum Light Emission from Lead Halide Perovskites
Th2G.4 – Thursday, 22 September, 11:45 – 12:15, Kairo
## Agenda of Sessions — Sunday, 18 September

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<th>Time</th>
<th>San Francisco</th>
<th>Samarkand + Osaka</th>
<th>Singapore</th>
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<td>WS02 • Role of Optical Network for Split Computing Between Edge and Cloud in Support of Ultra Low Latency Services</td>
<td>WS04 • Adaptive Everything! Do Optical Networks Really Need More Flexibility?</td>
<td>WS06 • F5G and Evolution Towards F&amp;G</td>
<td>WS08 • Life Above 100-GHz: Terahertz Device and System Challenges and Opportunities</td>
<td>WS10 • On-chip Mid-IR and THz Combs</td>
<td>WS12 • Heterogeneous Photonic Integrated Circuits</td>
<td>IONS+ Supercharge Your Conference Experience</td>
<td>WS14 • Linear Optics - A Solution for Efficient Machine Learning, Hard Problems Solving, Quantum and Microwave Technologies?</td>
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<td>WS14 • Linear Optics - A Solution for Efficient Machine Learning, Hard Problems Solving, Quantum and Microwave Technologies? II</td>
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<td>WS01 • Optical Networks - Will They Destroy the Planet or Save Humanity? I</td>
<td>WS03 • The Path towards Terabit/s PONs: Enabling Multi Gbit/s Data Rate Services</td>
<td>WS05 • Are Multi-band Optical Networks Simple Extensions of Traditional C-band Networks</td>
<td>WS07 • Which Technologies Will be Needed for 6G? I</td>
<td>WS09 • Moving from Optical Components in RAN to Optical Components for RAN</td>
<td>WS11 • Quantum Communication - Hype or Ripe? From QKD Networks to a Global Quantum Internet</td>
<td>WS13 • Photonic and Electronic Co-integration Solutions</td>
<td>IONS+ Supercharge Your Conference Experience</td>
<td>WS15 • Emerging Fiber Technologies For Transmission and Amplification I</td>
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<td>19:30–23:00</td>
<td>Gala Dinner, MS Rhystäm, Schifflände Basel</td>
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### Agenda of Sessions — Wednesday, 21 September

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Sessions</th>
</tr>
</thead>
</table>
| 08:00–17:30   | Registration, Entrance Hall 1 | We1A • Ultra-wideband Optical Systems (ends at 10:00)  
We1B • Network Planning and Cost Efficiency (ends at 10:00)  
We1C • Digital Optical Fiber Nonlinearity Mitigation  
We1D • Subsea Communications  
We1E • Heterogeneous Integration  
We1F • MW Photonics and Lidar  
We1G • Symposium: Nonlinear Optics in $\chi^{(2)}$/ $\chi^{(3)}$ Integrated Photonics  
We1H • 8th International Symposium for Optical Interconnect in Data Centres I |
| 10:15–10:45   | Coffee Break, Exhibition Hall 1 | We2A • DCI and Metro Transmission Systems (ends at 12:00)  
We2B • Control Plane and Automation  
We2C • Deep Learning for Optical Fiber Communications (ends at 12:15)  
We2E • Programmable Photonics and Comb Lasers  
We2F • Photonics Enabled Sub-Terahertz and Terahertz Systems  
We2G • Symposium: Diamond Nanophotonic Quantum Networks  
We2H • 8th International Symposium for Optical Interconnect in Data Centres II |
| 12:30–13:30   | Lunch Break - On Your Own | We3A • Topological Complex Light in Fibers and Devices  
We3B • QoT Estimation  
We3C • Coding and Modulation  
We3D • High-Speed Transmission  
We3E • Passive Photonic Functions  
We3F • Indoor and VLC Systems and Technologies  
We3G • Symposium: Quantum Communications - How Will Quantum Technology Revolutionize the Internet?  
We3H • 8th International Symposium for Optical Interconnect in Data Centres III |
| 15:15–15:45   | Coffee Break, Exhibition Hall 1 | We4A • Scattering and Nonlinear Effects in Fibers (ends at 17:00)  
We4B • Optical Networks for Sensing and Sensing for Optical Networks  
We4C • Digital Signal Processing for Novel Applications  
We4D • Wide-band Technologies and Transmission (ends at 17:15)  
We4E • Silicon Photonics  
We4F • Satellite Based Optical Freespace Communication II (ends at 17:15)  
We4G • Symposium: Photonic-Electronic Memristors for Neuromorphic Applications  
We4H • 8th International Symposium for Optical Interconnect in Data Centres IV |
| 17:30–19:00   | Rump Session: Analysis and Real Opportunities from the Hyped Big Trends in Photonics | We5 • Joint Poster Session II, Foyer 2nd Floor |

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*48th European Conference on Optical Communication • 18–22 September 2022*
## Agenda of Sessions — Thursday, 22 September

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Agenda</th>
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<tbody>
<tr>
<td>08:00–13:30</td>
<td></td>
<td>Registration, Entrance Hall 1</td>
</tr>
<tr>
<td>08:30–10:15</td>
<td>Samarkand + Osaka</td>
<td>Th1A • Novel Fiber Fabrication Methods (starts at 08:45, ends at 10:00)</td>
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<tr>
<td></td>
<td>Singapore</td>
<td>Th1B • Symposium: Free Space Optical Communication for Terrestrial &amp; Space Applications I</td>
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<tr>
<td></td>
<td>Sydney</td>
<td>Th1C • Novel Equalization Techniques</td>
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<td>Rio</td>
<td>Th1D • SDM Transmission and Monitoring Systems</td>
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<td></td>
<td>Boston</td>
<td>Th1E • High-speed Transmitter Devices</td>
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<tr>
<td></td>
<td>Shanghai</td>
<td>Th1F • Novel PICs and Applications</td>
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<td></td>
<td>Kairo</td>
<td>Th1G • Quantum Communication</td>
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<td></td>
<td>Delhi</td>
<td>Th1H • Symposium: Prospects for the Usage of Millimeter Wave Bands</td>
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<tr>
<td>10:15–10:45</td>
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<td>Coffee Break, Foyer, 2nd Floor</td>
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<tr>
<td>10:45–12:30</td>
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<td>Th2A • Single Core and Multicore Fiber Amplifiers</td>
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<td></td>
<td></td>
<td>Th2B • Symposium: Free Space Optical Communication for Terrestrial &amp; Space Applications II</td>
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<td>Th2C • High Baud Rate Transmission</td>
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<td>Th2D • Intra-data Centre Networks</td>
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<td>Th2E • Photodiodes and Photodetectors</td>
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<td>Th2F • Non-Linear Devices and Packaging</td>
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<td></td>
<td></td>
<td>Th2G • Quantum Photonics (ends at 12:15)</td>
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<td>Th2H • Symposium: Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO₂)</td>
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<td>12:30–13:30</td>
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<td>Lunch Break - On Your Own</td>
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<tr>
<td>13:30–15:00</td>
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<td>Th3A • Postdeadline Session III</td>
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<td>Th3B • Postdeadline Session I</td>
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<td>Th3C • Postdeadline Session II</td>
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<td>Th3D • Postdeadline Session IV</td>
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<tr>
<td>15:15–16:00</td>
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<td>Closing Ceremony, Singapore</td>
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</table>
Explanation of Session Codes

The first two letters of the code designates the day of the week (Mo = Monday, Tu = Tuesday, We = Wednesday, Th = Thursday). The second element indicates the session series in that day (for instance, 1 would denote the first parallel sessions in that day). The third element continues through a series of parallel sessions by room. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded Mo3A.4 indicates that this paper is being presented on Monday (Mo) in the third series of sessions (3), and is the first room of parallel session (A) in that series and the fourth paper (4) presented in that session.

**Mo3A.4**

<table>
<thead>
<tr>
<th>Day Of The Week</th>
<th>Number (Presentation order within the session)</th>
<th>Session Room Designation</th>
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<tbody>
<tr>
<td>Mo = Monday</td>
<td>(Presentation order within the session)</td>
<td>A = Samarkand + Osaka</td>
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<tr>
<td>Tu = Tuesday</td>
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<td>B = Singapore</td>
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<tr>
<td>We = Wednesday</td>
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<td>C = Sydney</td>
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<td>Th = Thursday</td>
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<td>D = Rio</td>
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<td>G = Kairo</td>
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<td>H = Delhi</td>
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**Session Room Designation**

- **A**: Samarkand + Osaka
- **B**: Singapore
- **C**: Sydney
- **D**: Rio
- **E**: Boston
- **F**: Shanghai
- **G**: Kairo
- **H**: Delhi

**Day Of The Week**

- **Mo**: Monday
- **Tu**: Tuesday
- **We**: Wednesday
- **Th**: Thursday

**Series Number**

- **1**: First Series of Sessions
- **2**: Second Series of Sessions
- **3**: Third Series of Sessions
- **4**: Fourth Series of Sessions
- **5**: Fifth Series of Sessions

**Technical Programme**

**08:00–19:00  Registration, Entrance Hall 1**

**San Francisco**

**18:00–19:00  Nobel Prize Lecture**

**Presiders: Juerg Leuthold, ETH Zurich, Switzerland**  
**Christoph Harder, Swissphotonics, Switzerland**

**18:00  Welcome Note, ECOC 2022 General Co-Chairs**

**Introduction of Nobel Prize Laureate, Joël Mesot**, President of ETH Zurich, Switzerland.

**18:05  Plenary**

*The Exoplanet Revolution*, Didier Queloz, ETH Zurich, Switzerland. The wealth and diversity of planetary systems that have now been detected modified our perspective on planet formation as a whole and more specifically our place in the Universe and the possibility of rarity of planetary systems similar to our own. It is also an opportunity of historical perspectives to look for signs of life on these new worlds as a way to explore our own origins. I will introduce the audience with the challenges of early discoveries and recent progresses in this new field of research and will touch upon the emergence of a new paradigm for the origins of life on Earth.

**19:00–21:00  Get Together Reception, Foyer 2nd Floor**
08:00–18:00 Registration, Entrance Hall 1

San Francisco

09:00–10:30
Mo1 • Opening Remarks and Joint Plenary Session I
Presider: Juerg Leuthold, ETH Zurich, Switzerland

Mo1.0 • 09:00
Opening Remarks, ECOC 2022 Organising Committee

Mo1.1 • 09:20
Plenary: Optical Communications in Space: Challenges and Opportunities, Elisabetta Rugi Grond; Thales Alenia Space Switzerland, Switzerland. The first activities in the field of optical communications for space applications are more than 25 years old. Nevertheless the use of this technology is still limited. Why? What has been done and what are today's fields of application and trends for the use of optical communication in space? What are the challenges and the opportunities? Many aspects such as standardization, interoperability, complexity, costs and business cases are driving the developments and the implementation of this technology in present and future space programs. A long term vision for a new era of space missions!

Mo1.2 • 09:50
Plenary: Scenarios of Future Innovations in the Network, David F. Welch; Infinera Corp, USA. Breakthrough innovations have allowed advancements in scale and cost in the networks. Improved materials, device concepts, impairment mitigations, and basic network structure have all enabled the network to scale in capacity while simultaneously and necessarily simplifying. Another series of radical innovation and rearchitecting of the network will be needed to accommodate the continued increasing scale, the movement of data centers to the edge, the expansion of the on-network devices and the variability of latency requirements, all while reducing the overall power required to run the network. The demands of the future networks and some thoughts on what will be required to address them will be discussed.

10:20–11:00 Coffee Break, Exhibition Hall 1

11:00–12:00
Mo2 • Joint Plenary Session II
Presider: Christoph Harder, Swissphotonics, Switzerland

Mo2.1 • 11:00
Plenary: Never Say Never Again, Christoph Glingener; ADVA Optical Networking AG, Germany. We work in an optical networking industry driven by pure innovation and built on highly precise science. We are the foundation of today's modern world. But considering our creativity and ingenuity, we sometimes dismiss an idea or a technology only for it to become a mainstay. In this keynote, Dr. Christoph Glingener reflects on some of the key technical advances that weren't always obvious and became some of the industry's biggest successes with widespread adaptation. If you learn only one thing in this talk, it's that in optical networking, never say never again.

Mo2.2 • 11:30
Plenary: Path to a Useful Quantum Computer, Mark G. Thompson; PsiQuantum Corp, USA. Quantum computing will have a profound impact on mankind's ability to process information, and will enable an increase in computational power at an unimaginable scale, for solving problems across climate, healthcare, energy, agriculture, transportation, manufacturing and beyond. However, to-date no quantum computer has outperformed even relatively modest high performance computers (HPC) at commercially useful tasks. Quantum error correction and scaling to millions of physical qubits are required for commercially relevant quantum computing. Of the various technological approaches being pursued, photons are unique in offer a path that overcomes the scaling challenges of manufacturability, cooling power, control electronics and quantum interconnects - through leveraging established CMOS manufacturing and silicon photonics. In this plenary talk, Dr Thompson will give an overview of PsiQuantum's approach to quantum computing, outlining the principles of photonic quantum computing, introducing the integrated quantum photonic circuit and highlighting the path to large-scale quantum computing.

12:00–13:30 Lunch Break - On Your Own
Mo3A.1 • 13:30  Tutorial

Al-Driven Digital Twin for Optical Networks, Qunbi Zhiuge1, Xiaomin Liu1, Yihao Zhang1, Meng Cai1, Yichen Liu1, Qizhi Qiu1, Lilin Yi1, Weisheng Hu1; 1Shanghai Jiao Tong Univ., China. Building digital twin for self-driving optical networks requires physical layer modeling, impair-ment monitoring and adaptive learning technologies. This tutorial will review the recent advances on these aspects, focusing on the adoption of AI algorithms and methodol-ogies to enable full-life cycle assessment of network status.

Mo3B.1 • 13:30  Invited

New Trends in Low Margin Optical Networks, Jelena Pesic1, Nokia Bell Labs, France. Abstract not available.

Mo3C.1 • 13:30  Invited

Optical Access Networks for Mobile Communications, Fabienne Saliou; Orange Labs, France.

Mo3B.2 • 14:00  Highly Scored

Low-Margin Optical-Network Design with Multiple Physical-Layer Parameter Uncertainties, Oleg Karandin1, Alessio Ferrari1, Francesco Musumeci1, Yvan Pointurier1, Massimo Tomatorte1; Politecnico di Milano, Italy; 1Hua-wei Technologies France, Paris Research Center, France. Analytical QoT models require safety margins to account for uncertain knowledge of input parameters. We propose and evaluate a design procedure that gradually decreases these margins in presence of multiple physical-layer uncertainties, by leveraging monitoring data to build a ML-based QoT regressor.

Mo3C.2 • 14:00

Evaluating Bandwidth Efficiency and Latency of Scheduling Schemes for 5G Fronthaul Over TDM-PON, Sarvesh S. Bidkar1, Konstantinos (Kostas) Christodouloupolou1, Thomas Pfeiffer1, Rene Bonk1; Nokia Bell Labs, Germany. We propose scheduling schemes for Cooperative DBA in upstream TDM-PON to enable 5G fronthaul services and evaluate their bandwidth efficiency and latency performance against FBA and conventional DBA using a co-simulation of a 25GS-PON MAC and a 5G system level simulator.

Mo3D.1 • 13:30

Reducing the Error Floor of the Sign-Preserving Min-Sum LDPC Decoder via Message Weighting of Low-De-gree Variable Nodes, Lotte M. Paulissen1, Alex Alvarado1, Kaiquan Wu1, Alexios Balatsoukas Stimming1, Eindhoven Univ. of Technology, Netherlands. Some low-complexity LDPC decoders suffer from error floors. We apply iteration-dependent weights to the degree-3 variable nodes to solve this problem. When the 802.3ca EPON LDPC code is considered, an error floor decrease of more than 3 orders of magnitude is achieved.

Mo3D.2 • 13:45  Highly Scored

Improved Soft-Aided Decoding of Product Codes with Adaptive Performance-Complexity Trade-off, Sisi Miao1, Lukas Rapp1, Laurent Schmalen1, Karlsruhe Institut fur Technologie, Germany. We propose an improved soft-aided decoding scheme for product codes that approaches the decoding performance of conventional soft-decision TPD with only a 0.2 dB gap while keeping the complexity and internal decoder data flow similarly low as in hard decision decoders.

Mo3D.3 • 14:00

Low Power Four-Dimensional Multi-Level Coding, Chunpo Pan1, yoones hashemi1, Masoud Barakat1n, Deyuan Chang1, Frank R. Kschischang1, zhuohong zhang1, Chuandong Li1, Huawei Technologies Co Ltd, Canada; 1Electrical and Computer Engineering, Univ. of Toronto, Canada. A novel four-dimensional multi-level coding architecture is proposed in which only 1.5 bit/complex symbol are soft decoded, leading to an additional 25% power savings compared to existing coding architectures. Simulation results confirm that these savings are achieved without performance loss, while maintaining compatibility with probabilistic-constellation-shaping.
Switzerland, while a small country, has a long tradition of excellence in Science and Technology with recognized worldwide impact. This tradition is perpetuated by research made in public institutions and cutting-edge technical products developed and commercialized by companies. In this symposium, prominent examples, arranged in an appealing program, will be presented by leading actors. The different subjects, providing a link to current and future optical communication technologies, will cover industrial atomic clocks, time and frequency dissemination in science and industry, brilliant light sources from synchrotron and free-electron lasers, and optical frequency combs as instrument calibrator for exoplanet search.

See page 17 of this programme for a list of speakers and topics for this Symposium.

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**Mo3F.1 • 13:30**
**New SOA Based ASE Source Module with High Power, Flat Output Spectrum and Low PDL, Antonin Gallet1, Nayla El Dahdahi1, Shuqi Yu1,2, Josef Demirtzoglou1, Gabriel Charlet2, Romain Brenot1; 1Huawei Technologies France S.A.S.U, France; 2Telecom SudParis, France.**

We propose a new ASE source module configuration based on two SOA for future WDM systems. With carefully selected SOA chips, 1-dB flat output spectrum and low PDL (0.2 dB) are achieved and up to 145mW output power is reported over the L-band at 30°C.

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**Mo3F.2 • 13:45**
**Large Aperture Receiver Based on Co-Packaged Micro-Lens and PD Arrays for Indoor GbE OWC Links, Yuchen Song1,2, Chenhui Li1, Ketema A. Mekonnen1, Eduward Tangeliongga1, Marc Spiegelberg, Oded Raz; 1Technische Universität Eindhoven, Netherlands.**

A new concept of co-packaging of a bespoke micro-lens array on a 4×4 photodiode OWC receiver is demonstrated, leading to more than 3 dB improvement in received power efficiency for GbE application. The concept is scalable to higher speed operation and more compact OWC receivers.

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**Mo3F.3 • 14:00**
**High-Bandwidth InP MZ/IQ Modulator PIC Ready for Practical Use, Yoshihiro Ogiso1, Josuke Ozaki2, Yasuaki Hashizume3; 1Nihon Denshin Denwa Kabushiki Kaisha, NTT Photonics Laboratories, Japan.**

We present our recent work on a next-generation of high-bandwidth InP MZ/IQ optical modulator PIC which is ready for practical use in 130-Gb/s-class transmitters. The PIC exhibits superior optical properties with over 67 GHz bandwidth.
We leverage data science to...
Mo3F.4 • 14:30
Wafer-Scale Fabrication of low-Loss Waveguides in Lithium Niobate on Insulator (LNOI) Integrated Photonics Platform, Jacopo Leo1, Mohan Hayati1, Farzad Ebrahimi Agri1, Zyad Haddad1, Gregory Choong1, Yves Petremand1, Ivan Prieto1, Olivier Dubochet1, Michel Despont1, Hamed Sattari1, Amir Ghadimi1; 1Centre Suisse d’Electronique et de Microtechnique SA, Switzerland. Here, we present a wafer scale fabrication for low-loss lithium niobate on insulator (LNOI) waveguides at C-band and statistical measurements of resonators, demonstrating quality factors exceeding 2.5x10^6, corresponding to a waveguide loss below 0.14 dB/cm.

Mo3F.5 • 14:45
A Polarization-Independent Zig-Zag-Tilted Ovals Grating Coupler in a 0.25 μm Photonic BiCMOS Technology, Galina Georgieva1, Pascal Seiler1,2, Christian Mai2, Anna Peczak1, Klaus Petermann1, Lars Zimmermann1,2; 1Technische Universität Berlin, Germany; 2IHP - Leibniz Institut für innovative Mikroelektronik, Germany. A polarization-independent grating coupler, optimized for a low in-plane scattering and PDL is presented. It comprises an array of ovals with zig-zag orientations and is compatible with a 0.25 μm photonic BiCMOS technology. The wafer-averaged maximal PDL within a 20 nm bandwidth is 0.5 dB.

Mo3G.3 • 14:15
Generation of Strong Parametric Fluorescence in a Highly-Nonlinear Silicon Nitride Waveguide with a Simple Pulsed Pump Source, Ping Zhao1, Zhichao Ye1, Magnus Karlsson1, Victor Torres-Company1, Peter Andrekson1; 1Chalmers Univ. of Technology, Sweden. We present the generation of strong parametric fluorescence based on the spontaneous four-wave mixing in a highly-nonlinear silicon nitride waveguide pumped by a simple C-band pulsed pump. Parametric fluorescence spanning over 100 nm with a maximum power spectral density of -25 dBm/ nm is experimentally achieved.

Mo3G.4 • 14:30
Highly Scored
Photon Emission by Si-Based Memristors, Till Zellweger1,2, Bojun Cheng3, Konstantin Malchow3, Aymeric Leray1, Jan Aeschlimann2, Mathieu Luisier1, Alexandros Embaras1, Alexandre Bouhelier3, Juerg Leuthold1; 1Inst. of Electromagnetic Fields, Eidgenossische Technische Hochschule Zurich, Switzerland; 2Integrated Systems Laboratory, Eidgenossische Technische Hochschule Zurich, Switzerland; 3Laboratoire Interdisciplinaire Carnot de Bourgogne, Universite de Bourgogne, France. We introduce a new category of nanoscale photon sources based on memristors with silicon-based switching matrices. These novel photon sources exhibit light emission during the switching of their resistive state. The photon emission is attributed to the creation and excitation of silicon nanoclusters.

Mo3G.5 • 14:45
Topological Photonic Devices, Merzede Khajavikhan1; 1Univ. of Southern California, USA. Abstract not available.
Nonlinear Fiber Transmission of Compressed Shaping Signals, Tsuyoshi Yoshida1,2, Takashi Inoue1, Koji Igarashi2, Masashi Binkai1, Yoshiaki Konishi1, Naoki Suzuki1, Magnus Karlsson1, Erik Agrell1; 1Information Technology R&D Center, Mitsubishi Electric Corporation, Japan; 2Graduate School of Engineering, Osaka Univ., Japan; 3National Inst. of Advanced Industrial Science and Technology, Japan; 4Fiber Optic Communications Research Center, Chalmers Univ. of Technology, Sweden. In nonlinear transmission of compressed shaping signals, the optimum launch power decreases as source entropy decreases, but the maximum Q performance based on soft information increases for either bit-interleaved coded or multilevel coded modulation. The excess degradation is mostly recovered by high-performance multi-channel nonlinearity compensation.
Mo3F.6 • 15:00
Impact of Seed Annealing on the Reliability of Monolithic GaAs/Si p-n Diode Optical Phase Shifters, Artemisia Tsiara,1 Yoonghyun Kim,2 Didit Yudistira,2 Bernadette Kunert,1 Marina Baryshnikova,1 Marianna Pantouvaki,3 Joris Van Campenhout,1 Kristof Croes,1 ‘Interuniversitair Micro-Elektronica Centrum, Belgium; 1Department of Photonics and Nanoelectronics, Hanyang Univ. College of Science and Convergence Technology, Korea (the Republic of); 3Microsoft Research Ltd, UK. We report the reliability assessment of carrier-depletion p-n diode GaAs/Si optical modulators monolithically integrated on a 300-mm Si wafer. Dark current remains stable under long accelerating aging tests. Devices without seed annealing experience a shift of $V_π, L$ with no stress temperature dependence.

15:15–15:45 Coffee Break, Exhibition Hall 1
Mo4A.1 • 15:45
Fibre Type Identification: Alleviating Ambiguities, Emmanuel Seve, Sebastien Bigo, Patricia Layez; Nokia Bell Labs, France, France. We correlate accumulated dispersions measured in coherent receivers to autonomously identify fibre types in a network without traffic interruption. We propose two techniques to cope with ambiguities: one for ranking solutions by likeliness and one for accelerating their extraction by x100 without enumerating all solutions.

Mo4A.2 • 16:00 Highly Scored
Continuous Fiber Sensing Over Field-Deployed Metro Link Using Real-Time Coherent Transceiver and DAS, Mikael Mazur, Neil Parkin, Roland Ryf, Asif Iqbal, Paul Wright, Kristian Farrow, Nicolas K. Fontaine, Erik Borjeson, KW Kim, Lauren Dallachiesa, Haoshuo Chen, Per Larsson-Edefors, Andrew Lord, David T. Neilson; Nokia Bell Labs, USA, BT, UK; Chalmers tekniska hogskola, Sweden. We use an FPGA-based real-time coherent transceiver prototype with continuous us-level state-of-polarization readouts and a commercial DAS system to perform fiber sensing. Link monitoring and active detection of link tampering is demonstrated using both systems, showing how SOP-based sensing complements DAS in metro environments.

Mo4A.3 • 16:15 Invited
Optical Fiber Networks for Environmental Sensing, Valey Karnalov; Google LLC, USA. Coherent detection enables linearization of signal but also provides an opportunity to look into linear noise properties. Fourier transformation opens a sub-Hz spectral window where we monitor earthquakes and water waves using trans-oceanic submarine cable spectrometers.

Mo4B.1 • 15:45 Tutorial
Resource Orchestration in Support of Edge Computing in Optical Networks, Emmanuel Varvarigos; National Technical Univ. of Athens, Greece. Extending the cloud resources to the network’s periphery, commonly known as edge computing, has been recognized as the key in overcoming critical challenges in data collection, transmission, and processing in centralized computing systems. The realization of the edge-cloud continuum is based on the movement of data and workload from the devices, to the edge and the core cloud and vice versa. This horizontal (edge-to-cloud) and vertical (edge-to-edge) movement requires efficient allocation of optical networking resources in the core, the metro, and the access segments that usually belong to different administrative domains. In this continuously evolving environment, the joint allocation of networking and computing resources can significantly improve the provided QoS, while increasing the utilization of the resources. These problems can be mitigated through the development of appropriate resource orchestration mechanisms that consider the application requirements and the different resource characteristics during the resource allocation process and utilize the necessary tools for resource management and monitoring.

Mo4B.2 • 16:15
Low Bandwidth APD Receiver Assessment with Fixed FIR Filter and SOA for Multi-Rate and Several Wavelength of Class N1 and C+ of Higher Speed PONs, Georges Gaillard, Fabienne Saliou, Jeremy Potel, Gael Simon, Philippe Chanclou, Flavio Nogueira Sampaio; Orange, France. A 17GHz APD-TIA followed by an optimized analog 6-taps FIR filter is demonstrated for up to -27dBm sensitivities at 25G and 50Gbit/s, for downstream (continuous) and upstream wavelength options (burst mode), for 0 and 20km of fiber, with the help of an SOA preamplifier.

Mo4C.1 • 15:45 Invited
Chartering the Future of Optical Access Networks, Jun Shan Wey, Denis Khotimsky; Verizon Communications Inc, USA. Whereas the access segment of data communications was a relatively late adopter of optical technologies compared with backbone and metro, it quickly became the main battleground. Based on Verizon’s experience, we analyze the operator’s broadband strategy, review the standardization landscape, and discuss recent innovations in optical access.

Mo4C.2 • 16:15
Modulation-Format Dependent Impact of Modal Dispersion on Cross-Phase Modulation in SDM Transmission, Chiara Lasagni, Paolo Serena, Alberto Bononi, Cristian Antonelli; Università degli Studi di Parma, Italy; Università degli Studi dell’Aquila, Italy. We show that the interplay between spatial mode dispersion (SMD) and the modulation format has a substantial impact on cross-phase modulation (XPM) in space-division multiplexed systems with strongly coupled modes. We propose a simple formula to account for SMD in the modulation-format-dependent XPM contribution.
Switzerland, while a small country, has a long tradition of excellence in Science and Technology with recognized worldwide impact. This tradition is perpetuated by research made in public institutions and cutting-edge technical products developed and commercialized by companies. In this symposium, prominent examples, arranged in an appealing program, will be presented by leading actors. The different subjects, providing a link to current and future optical communication technologies, will cover industrial atomic clocks, time and frequency dissemination in science and industry, brilliant light sources from synchrotron and free-electron lasers, and optical frequency combs as instrument calibrator for exoplanet search.

See page 17 of this programme for a list of speakers and topics for this Symposium.

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**Boston**

**15:45–17:15**  
**Mo4E • Swiss Symposium - Light and Time II**  
Organiser: Steve Lecomte; CSEM, Switzerland

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**Delhi**

**15:45–17:30**  
**Mo4H • Symposium on 50 Years of Fibre Optics II**  
Organisers: Francesco Poletti; University of Southampton, UK  
Tommy Geisler; OFS, Denmark

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**Shanghai**

**15:45–17:15**  
**Mo4F • (B)ICMOS Optoelectronics**  
Presider: Xin Yin; IMEC - Ghent Univ., Belgium

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**Kairo**

**15:45–17:15**  
**Mo4G • Novel Photonic Platforms and Sources I**  
Presider: Marta De Luca; Universitat Basel, Switzerland

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**Mo4F.1 • 15:45**  
Class-80 InP-Based High-Bandwidth Coherent Driver Modulator with Flexible Printed Circuit RF Interface, Josuke Ozaki1, Yoshihiro Ogiso1, Yasuaki Hashizume1, Hiroshi Yamazaki2, Kazuya Nagashima1, Mitsuteru Ishikawa1; 1NTT Device Innovation Center, Nippon Telegraph and Telephone Corporation, Japan; 2Telecommunications & Energy Laboratories, Furukawa Denki Kogyo Kabushiki Kaisha, Japan.

We developed flexible printed circuit RF interface InP-based coherent driver modulators with a 3-dB bandwidth of over 80 GHz for 128-Gbaud or higher operations. Low insertion loss (<8.5 dB per polarization), low polarization-dependent loss (<0.1 dB), and high extinction ratio (>30 dB) were achieved.

**Mo4F.2 • 16:00**  
60 GHz Analog Radio-Over-Fiber Single Sideband Transmitter Chipset With 55nm SiGe BiCMOS Driver RFIC and Silicon Photonics Modulator PIC, Nishant Singh1, Joris Van Kerrebrouck1, Piet Demeester1, Xin Yin1, Guy Torfs1; 1IDLab UGent-imec, Belgium. An all-silicon transmitter chipset is presented for narrowband operation in the unlicensed 60 GHz band. The PIC consists of parallel electro-absorption modulators and thermo-optic phase shifters which are driven with both in-phase and quadrature components by the RFIC. A sideband suppression ratio of 25 dB is demonstrated with a full chipset size of 1.1 mm² and a power consumption of 45 mW. Link experiments are conducted with QAM signals.

**Mo4F.3 • 16:15**  
CMOS Transceiver Circuits for Energy Efficient Silicon Photonic Interconnects, Peng Yan1, Po-Hsuan Chang1, Anirban Samanta1, Chaerin Hong1, Hyungryul Kang1, Odedeepta Annabattula1, Ankur Kumar1, Yang-Hang Fan1, Ruida Liu1, S. J. Ben Yoo1, Samuel Palermo1; 1Texas A&M Univ., USA; 2Univ. of California Davis College of Engineering, USA. Energy efficient transceivers are necessary to scale optical interconnect performance well below 500Gb/s. We discuss our circuit design work in CMOS transmitter and receiver front-ends optimized for silicon photonic microring resonator-based wavelength division multiplexing interconnects.

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**Mo4G.1 • 15:45**  
3D Laser Printing Based on Two-Step Absorption, Martin Wegener1, Karlruher Institut für Technologie, Germany.

We review our recent work on two-step absorption instead of two-photon absorption for 3D laser printing. This includes single-color two-step absorption for focus-scanning 3D laser nanoprinting and two-color two-step absorption for parallelized light-sheet 3D microprinting.

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**Mo4G.2 • 16:15**  
Self-Assembled Dewetting as a Fabrication Platform for Photonics Applications, Pierre-Luc Fivetreau1, Louis Martin-Monier1, Tapajoyi Das Gupta1, Bastien Schym1, William Esposito1, Fabien Sorin1; 1Ecole Polytechnique Federale de Lausanne Faculte des Sciences et Techniques de l’Ingenieur, Switzerland; 2Massachusetts Inst. of Technology, USA; 3Indian Inst. of Science, India. A novel fabrication method based on controlled fluid re-arrangement of thin amorphous optical glass film is leveraged to realize two large-area photonics metasurfaces: 1) a highly directional nano-antenna array (metareflector), and 2) a metamaterial for index sensing.
TLC-compatible coherent interferometric localization, demonstrating fruitful synergy between monitoring and traffic sensing, but also diagnostic and strategies applied to already deployed fiber networks Milano, Italy.

Fiber Infrastructures, Sensing Applications in Deployed Telecommunication Networks, Pierpaolo Soffi, Politecnico di Milano, Italy TLC-compatible coherent interferometric strategies applied to already deployed fiber networks are presented to provide not only current structures health monitoring and traffic sensing, but also diagnostic and surveillance of the infrastructure integrity and damages localization, demonstrating fruitful synergy between telecommunication and sensing applications.

Scheduling Synchronization Supporting Ultra Reliable Low Latency Communications (URLLC) in Cloud-RAN Over Virtualised Mesh PON, Sandig Das, Frank-Slyne, Daniel Kilper, Marco Ruffini, Trinity College Dublin, Ireland. We propose a mechanism to support URLLC Open-RAN ultra-low latency over a MESH-PON, serving dense deployment of small cell and MEC nodes in an access network. We show the possibility, under given assumptions, to achieve application-to-application end-to-end latency below 1ms.

Triple Coexistence of PON Technologies: Experiments of G-PON, XGS-PON and 50G(S)-PON Over a Class C+ ODN, Fabienne Saliou, Georges Gaillard, Gael Simon, Stephane Le Huerou, Jeremy Potet, Philippe Chancroux, Orange, France. With measurements from the field and commercial MFP modules, we demonstrate experimentally how 50G-PON upstream wavelength plan can be adopted to coexist with both G-PON and XGS-PONs. DSP free 50Gbit/s burst mode upstream is then demonstrated in overlay with 10km of fibre and -27dBm sensitivity.

EXPERIMENTAL ANALYSIS OF TDEC FOR HIGHER SPEED PON INCLUDING LINEAR EQUALIZATION, Gaeil Simon, Flavio Nogueira Sampaio, Fabienne Saliou, Jeremy Potet, Philippe Chancroux, Orange, France. TDEC is the reference metric to characterize transmitters in terms of sensitivity and penalty, in downstream HS-PON. We investigate on the capacity estimation of submarine open cables. We show that throughput can be predicted within 4% when the system operates close to the optimal power.

Mo4C.4 • 16:45
Experimental Analysis of TDEC for Higher Speed PON Including Linear Equalization, Gaeil Simon, Flavio Nogueira Sampaio, Fabienne Saliou, Jeremy Potet, Philippe Chancroux, Orange, France. TDEC is the reference metric to characterize transmitters in terms of sensitivity and penalty, in downstream HS-PON. We investigate on its tolerance and focus on the noise enhancement factor “Ceq”. We plead for a clarification in the method to determine the optimal equalizer.

Mo4D.3 • 16:30
Modelling of Cable Capacity and Relative Cost/bit Between Amplification Options for Submarine MCF Systems, John D. Downie, Yongmum Jung, Sergey Makovey, Merion Edwards, David Richardson, Corning Inc, USA.

Between Amplification Options for Submarine MCF Systems, John D. Downie, Yongmum Jung, Sergey Makovey, Merion Edwards, David Richardson, Corning Inc, USA. We examine amplification options for repeatered submarine systems using multicore transmission fibre in the context of relative cable capacity and system cost/bit. Multicore EDFA systems using either core-pumping or cladding pumping could offer lower cost/bit than parallel single-core EDFA but cladding pumping may reduce cable capacities.

Mo4D.5 • 17:00
Capacity Prediction from Commissioning Parameters of Subsea Open Cables, Joana Girard-Jollet, Jean-Christophe Antone, Alexis Carbo Meseguer, Matteo Landoni, Samuel Olsson, Vincent Letellier, Olivier Courtois. We examine the capacity impact of new features on the transceiver modes and of non-public line parameters on the capacity estimation of submarine open cables. We show that throughput can be predicted within 4% when the system operates close to the optimal power.
Mo4E • Swiss Symposium - Light and Time II—Continued

Mo4F • (Bi)CMOS Optoelectronics—Continued

Mo4G • Novel Photonic Platforms and Sources I—Continued

Mo4H • Symposium on 50 Years of Fibre Optics II—Continued

Mo4G.3 • 16:30
A Path Towards Attojoule Cryogenic Communication, Matteo Cherchi1, Emma Mykkänen1, Antti Kemppinen1, Kirs Tappuru1, Joonas Goverius1, Mikka Prunnila1, Giovanni Delrosso1, Teemu Hakkarainen1, Jukka Vihenläli2, Mario Castañeda1, Mark Bieler1, Stephan Steinhauer1, Val Zwiller1, Stefan Koepfler1, Juerg Leuthold1, Eva De Leo1; 1VTT Technical Research Centre of Finland, Finland; 2ORC, Tampereen yliopisto, Finland; 3Single Quantum B V, Netherlands; 4Physikalisch-Technische Bundesanstalt, Germany; 5Kungliga Tekniska Hogskolan, Sweden; 6Eidgenossische Technische Hochschule Zurich, Switzerland; 7Polariton Technologies AG, Switzerland. Photonic integration technologies are key to scale-up superconducting quantum computers. Here, we identify suitable classical optical links to control and read out the qubits in cryostats and resolve the power dissipation issue of superconducting computing platforms. Recent results and future solutions are shown.

Mo4G.4 • 16:45
Invited Nanowire Flexible Light Emitting Diodes, Solar Cells and Piezosensors, Maria Tchernycheva1; 1IEF, France. Abstract not available.

Mo4F.4 • 16:45
First Demonstration of an O-Band Coherent Link for Intra-Data Center Applications, Aaron Maharry1, Junqian Liu1, Stephen Miskal1, Hector Andrade1, Luis A. Valenzuela1, Giovanni Gilardi2, Hao-Hsiang Liao2, Ansheng Liu2, Yuliya A. Akulova3, Larry Coldren1, James F. Buckwalter1, Clint L. Schow1; 1Univ. of California Santa Barbara, USA; 2Intel Corp, USA. We report two first-of-a-kind achievements for integrated O-band coherent subsystems: a full coherent link at 112 Gbps (56 Gbaud QPSK) with 2.1×10⁻⁴ measured BER, and a record baud rate 128 Gbps (64 Gbaud QPSK) transmitter.

Mo4F.5 • 17:00
A Monolithic Polarization Tracking Loop Demonstrated on a 90nm Silicon CMOS-Photonic Platform, Po-Hsuan Chang1, Mingye Fu1, Peng Yan1, Anirban Samanta2, Mehmet Berkay On1, Yuanming Zhu1, S. J. Ben Yoo2, Samuel Palermo1; 1Texas A&M Univ., USA; 2Univ. of California Davis, USA. We report, to our knowledge, the first monolithically-integrated silicon CMOS-photonic codesigned polarization tracking circuit implemented in a 90nm SOI process. The circuit tracks randomized polarization rotation across the Poincare sphere, maximizes TE-mode optical power, and experimentally achieves a BER of 10⁻¹¹ with 10Gb/s PAM-2 modulation.

19:30–23:00 Welcome Reception, Markthalle Basel, Steinentorberg 20, 4051 Basel
With the help of Huawei Technologies Canada, Canada.

This paper proposes the following performance monitoring method for optical performance monitoring of digital subcarrier multiplexed signals using amplitude modulation pilot tones in spectral valleys. The estimation of OSNR and nonlinear interference noise is experimentally demonstrated with an enhanced robustness.


We propose a performance monitoring method for digital subcarrier multiplexed signals using amplitude modulation pilot tones in spectral valleys. The estimation of OSNR and nonlinear interference noise is experimentally demonstrated with an enhanced robustness.

4x75-Gbit/s Optically Amplified WDM-PON With Beyond 31-dB Power Budget Employing PAM-4 Transmission and a Recurrent Neural Network, Ahmed Galib Reza, Marcos Troncoso-Costas, Liam P. Barry, Colin Browning, Dublin City Univ., Ireland; El Telecomunicacion, Universidad de Vigo, Spain. This paper proposes the use of recurrent neural networks-based machine learning equalizers to mitigate the nonlinearities in SOA-based WDM-PON systems with 100-GHz channel spacing. We achieve >31-dB link budgets on each channel for 4x75-Gbit/s PAM-4 transmissions over 25-km of single-mode fiber at 1550-nm.

Closed Form Expressions of the Nonlinear Interference for UWB Systems, Pierluigi Poggiolini, Mehdi Ranjbar, Politecnico di Torino, Italy; CISCO Systems S.R.L., Italy. We present a comprehensive closed-form GN/EGN model supporting ultra-wide-band systems spanning 50 THz of optical bandwidth. We show a case-study of 10x100km of SMF where we gradually increase the number of channels across the C, L, S, U, E bands while optimizing launch power.
08:30–10:15
Tu1F • Co-Packaging and Large Photonic Circuits
Presider: Lars Zimmermann; IHP GmbH, Germany

08:30–10:15
Tu1G • Metadevices and High-speed Photonics
Presider: Giacomo Scalari; ETH Zurich, Switzerland

08:30–10:15
Training Course on Integrated Photonic Technologies I
Instructors: Hugo Thienpont; Vrije Universiteit Brussel, Belgium
Roel Baets; ePIXfab, Belgium
Kevin Williams; JePPiX, Netherlands
Peter O’Brien; Tyndall, Ireland
Jurg Van Erps; Vrije Universiteit Brussel, Belgium

See page 115 of this programme for more information about this event.

Tu1E.1 • 08:30 Tutorial
Silicon and Germanium Mid-IR Devices and Circuits, Goran Mashanovich, Univ. of Southampton, UK. Mid-infrared integrated photonics has become a very attractive research area due to a host of important applications. Silicon and germanium offer low-cost manufacturing of photonic circuits. In this tutorial I will cover recent progress in passive and active silicon and germanium mid-IR devices and circuits.

Tu1F.1 • 08:30 Invited
Key Technology Enablers for Co-Packaged Optics, Karl Muth, Vivek Raghuraman; OSD, Broadcom Ltd, USA. This paper shows the necessary technologies for a SiPh based optical I/Os merging mature silicon chiplet packaging and fiber connectivity to achieve the highest I/O efficiency (highest density, lowest power and cost). An early Broadcom prototype system is demonstrated, and main performance parameters are reported.

Tu1G.1 • 08:30
Plasmonic 100-GHz Electro-Optic Modulators for Cryogenic Applications, Patrick Habegger, Yannik Horst, Stefan Kaplit, Manuel Kohli, Eva De Leo, Dominik Bisang, Marcel Destraz, Valentin Tedaldi, Norbert Meier, Nino Del Medico, Wei Wang, Claudia Hoessbacher, Benedikt Baueuerle, Wolfgang Heni, Juerg Leuthold; Polariton Technologies AG, Switzerland; ITET, Eidgenössische Technische Hochschule Zürich, Switzerland. We demonstrate an energy-efficient, 100-GHz plasmonic modulator operating at 4K for beyond 128 Gb/s data modulation with ultra-low driving voltage of 0.1 V. High-speed components at cryogenic temperature are essential building blocks for scalable next-generation quantum computing systems.

Tu1G.2 • 08:45
RF-Injection Control of Quantum Cascade Lasers in the Time-Domain, Barbara Schneider, Philipp Täschler, Mathieu Bertrand, Filippos Kapsalis, Mathias Beck, Jerôme Fasit, ETH Zürich, Switzerland. In this work, we demonstrate control over the time-domain state quantum cascade laser output state using microwave modulation. We demonstrate narrow, pulse-like features with a full-width at half-maximum of 558 fs when isolated, which corresponds to the expected Fourier-transform limited pulse-width.

Tu1E • Mid-IR Devices and Circuits
Presider: Jörg Wieland; Tetra Semiconductors Ltd, Switzerland
Tu1A • High-Baud Rate Optical Communication—Continued

Tu1A.3 • 09:00
Is It Meaningful to Pursue Higher Symbol Rate Beyond Bandwidth Constraint for Short-Reach Interconnects?, Di Che,1, Nokia Bell Labs, USA. It is questionable whether higher symbol rate PAM-4 or higher-order modulation like PAM-6/8 is more suitable for the next-gen optical interface beyond 200G per lane. We reveal the advantage of pursuing higher symbol rate with faster-than-Nyquist (FTN) technique to break the bandwidth constraint, by comparing the achievable information rate between FTN and Nyquist signaling.

Tu1B • New Trends in Optical Networks—Continued

Tu1B.2 • 09:00
A Network Dimensioning Algorithm for Exploiting the Capabilities of Subcarrier-Based Point-to-Multipoint Coherent Optics, Pablo Pavan-Marino,1,2, Nina Skorin-Kapov,2, Antonio Napoli,1, Universidad Politecnica de Cartagena, Spain;2;E-lighthouse Network Solutions, Spain;2;Univ. Center of Defense, San Javier Air Force Base, Spain;2;Infinera Corp, Germany. We present the first generalized dimensioning algorithm for optical networks with sub-carrier-based Point-to-Multipoint (P2MP) coherent transceivers, that covers hub-spoke determination, transceiver allocation, along with light-tree routing and spectrum assignment, in arbitrary topologies. The benefits of P2MP optics in a metro-network case study are evaluated.

Tu1B.3 • 09:15
Dimensioning Networks of High Degree ROADMs, Hamid Mehrvar,1 Shiqiang Li,1 Eric Bernier,1; Huawei Technologies Canada, Canada;2;Huawei Technologies Co Ltd, China. A network dimensioning scheme is proposed for transparent optical networks equipped with many high degree ROADM cluster nodes. It uses network knowledge to determine the optimum degree of ROADM nodes as demand increases. The results show improved blocking and resource utilization compared to reactive schemes.

Tu1B.4 • 09:30
Optoelectronic Feedforward Equalization: Simple 1-tap Optical Delay Line and Ethernet-Compliant Linear FFE Enabling C-Band 100G PAM4 Over ER+ Distance, Pakun Zhu,1 Yuki Yoshida,1 Atsushi Kanor,1 Ken-ichi Kitayama,1,2; Hamamatsu Photonics Kabushiki Kaisha Chuo Kenkyuyo, Japan;1;Kokusetsu Kenki Kyatsu Heijin Joho Tsushin Kenkyu Kiko, Japan. Ultimately low-complexity optoelectronic feedforward equalization (OE-FFE) scheme is investigated both analytically and experimentally for dispersion-limited high-speed IM/DD PAM4 systems. 6.7% HD-FEC-compliant BERs are achieved for C-band 100Gb/s and 112Gb/s over 50km with 1-tap optical delay line and 19-tap / 31-tap linear FFE only.

Tu1C • Quantum and Future Access Technologies—Continued

Tu1C.3 • 09:00
Key Components of Bidirectional Transceivers for Access Network at 100Gbit/s and Beyond, Hirofusa Nakamura,1; NTT Corporation, Japan. 1000Gbit/s and beyond bidirectional systems are expected to play a very important role in next high-speed optical access networks. This paper introduces its requirements and key components of bidirectional transceivers using the latest technologies.

Tu1C.4 • 09:30
Is There Room for Quantum Photons in my Access Network?, Annachiara Pagano,1 Antonio Manzalini,1 Maurizio Valvo,2; TELECOM ITALIA, Italy. Quantum Key Distribution is gaining momentum as an ultimate solution for network security. The paper provides the network operator’s point of view about the deployment of a quantum key distribution optical layer in metro-access, discussing resource sharing and constraints related to the coexistence of heterogeneous optical technologies.

Tu1D • Nonlinear Transmission Modeling—Continued

Tu1D.2 • 09:00
Generalized Raman Scattering Model and Its Application to Closed-Form GN Model Expressions Beyond the C+L Band, Chiara Lasagni,1 Paolo Serena,1 Alberto Bononi,1 Jean-Christophe Antoni,1; Universita degli Studi dell’Aquila Dipartimento di Scienze Fisiche e Chimiche, Italy;2;Acaltec Submarine Networks, France;3;Universita degli Studi di Parma, Italy. We derive a wide-band approximation of the stimulated Raman scattering formula and show its application to Gaussian noise (GN) model closed-form expressions for transmissions even beyond the C+L band.

Tu1D.3 • 09:15
An Extended Version of the ISRS GN Model in Closed-Form Accounting for Short Span Lengths and Low Losses, Henrique Bligua,1 Eric Sillekens,2, A Vaslychekova,1 Robert Killey,1 Polina Bayvel,1 Lidia Galdino1,2; Univ. College London, UK. A closed-form formula for the nonlinear interference (NLI) estimation of arbitrary modulation formats, supporting short span lengths and low losses in ultra-wideband optical transmission systems is presented. The formula is tested over 20 THz and accurately estimates the NLI at every point of the fibre span.

Tu1D.4 • 09:30
Model for Nonlinear Interference Noise in Raman-Amplified WDM Systems, Francesco Lorenzi,1 Gianluca Marcon,1 Andrea Galtarossa,1 Luca Palmieri,1 Antonio Meccozzi,1 Cristian Antonelli,1,2 Marco Santagiustina,1; Department of Information Engineering, Universita degli Studi di Padova, Italy;2;Department of Physical and Chemical Sciences, Univ. of L’Aquila, Italy. An extension of the model of NLI to Raman amplified links is presented, in the context of WDM systems. Noise estimation is obtained for an 80km amplified link with optimized pump placement, in co- and counterpropagating regime, for a C+L band configuration.
Tu1F.2 • 09:00
An 800 Gb/s, 16 Channel, VCSEL-Based, co-Packaged Transceiver With Fast Laser Sparing, Daniel Kuchta1, Mounir Meghelli1, Petar Pepeljugoski1, Laurent Schaeres1, Mark Schultz1, Pavlos Maniortis1, Paul Fortier1, Charles Bureau1, Marc-Olivier Pion1, Yvan Coiset1e, Guillaume Jutras1, Bory Sow1, Bakul Parikh1, Steve Ostrandern, Shidong Li1, Dale Becker1, Faezah Gholami1, Harry Baghen1, Frank Fiensa, Greta Light1, Bill Wang3, IBM TJ Watson Research Center, USA; 1IBM Bromont, Canada; 1IBM Systems, USA; 1/II-VI Finisar, USA. We report on high speed, low power, and sparing characteristics of the transmitter portion of an 800 Gb/s co-packaged transceiver using VCSELs and 2:1 sparing for improved reliability. The transmitter consumes 2.7 pJ/bit including the laser. The spare VCSEL can be enabled in < 100ns.

Tu1F.3 • 09:15
Demonstration of Silicon-Photonics Hybrid Glass-Epoxy Substrate for Co-Packaged Optics, Akihiro Nonkii1, Akio Ukita1, Koichi Takemura1, Satoshi Suda1, Takayuki Kurosua1, Yasuhisa Ibusuki1, Isao Tama1, Daisuke Shimura1, Yusuke Onawa1, Hiroki Yaegashi1, Takeru Amano1; 1Natl Inst of Adv Industrial Sci & Tech, Japan; 2Photonics Electronics Technology Research Association (PETRA), Japan. To realize a new package substrate for co-packaged optics, silicon-photonics hybrid glass-epoxy substrate with optical redistribution layer was demonstrated. 112 Gbps PAM-4 transmissions through the hybrid substrate were demonstrated with the TDECQ less than 3.4 dB.

Tu1F.4 • 09:30
Photonic Circuits for Accelerated Computing Systems, Benjamin G. Lee1, NVIDIA Corporation, USA. GPU-based accelerated computing is powering the AI revolution. These systems include processors and switches which push thermal power density limits while demanding large I/O bandwidths. To continue scaling, very dense integration of ultra-efficient optical transceivers is called for to alleviate current inefficiencies in off-package signalling.

Tu1G.3 • 09:00
Invited
Introducing Reconfigurability in Planar Metasurfaces, Romain Quidant1; 1ETH Zurich, Switzerland. In this talk we present our most recent advances in the development of reconfigurable planar optical elements, with two original technologies: micron-scale engineering of the thermo-optical effect and optomechanical control.

Tu1G.4 • 09:30
Invited
Molecular Optomechanical Springs for Infrared Metasurface Detectors, Angelos Xomalis1; 1IESL.FORTH, Greece. Abstract not available.
Tu1A • High-Baud Rate Optical Communication—Continued

Tu1B • New Trends in Optical Networks—Continued

Tu1B.5 • 09:45 Invited
Time Sensitive Networking for 5G and Beyond, Jun Terada; NTT Access Service Systems Laboratories, Japan. Abstract not available.

Tu1C • Quantum and Future Access Technologies—Continued

Tu1C.5 • 10:00 DAC/ADC-Free 65536-Level Quantum Noise Stream Cipher for Secure Fiber Transmission Based on Delta-Sigma Modulation, Hanwen Luo1,2, Linsheng Zhong1,2, Shennao Zhang1,2, Xiaoxiao Dai1,2, Lei Deng1,2, Deming Liu1,2, Mengfan Cheng1,2, Qi Yang1,2; 1Huazhong Univ. of Science and Technology, China; 2Shenzhen Huazhong Univ. of Science and Technology Research Institute, China. We demonstrate a DAC/ADC-free 65536-level quantum noise stream cipher communication with asynchronous clock over 70-km SMF using delta-sigma modulation. Adjusting the oversampling rates of delta-sigma modulation can achieve flexible adjustment of security, stability, and cost.

Tu1D • Nonlinear Transmission Modeling—Continued

Tu1D.5 • 09:45
Analytical SNR Prediction in Long-Haul Optical Transmission Using General Dual-Polarization 4D Formats, Zhiwei Liang1, Bin Chen1, Yi Lei1; Gabriele Liguori1, Alex Alvarado1; 1Hefei Univ. of Technology, China; 2Technische Universiteit Eindhoven, Netherlands. Nonlinear interference models for dual-polarization 4D(DP-4D) modulation have only been used so far to predict signal-signal nonlinear interference. We show that including the signal-noise term in the prediction of the effective signal-to-noise ratio in long distance DP-4D transmission improves the accuracy by up to 0.2dB.

Tu1D.6 • 10:00
Closed-Form Expressions for Fiber-Nonlinearity-Based Longitudinal Power Profile Estimation Methods, Takeo Sasai1, Etsushi Yamazaki1, Masanori Nakamura1, Yoshiaki Kisaka1; NTT Corporation, Japan. Closed-form expressions for longitudinal power profile estimation methods (correlation and MMSE) are derived. Findings indicate that the spatial resolution of correlation methods is inherently limited even in noise-less and distortion-less conditions, while MMSE methods do not suffer from such limitation.

10:15–10:45 Coffee Break, Exhibition Hall 1

12:30–13:30 Lunch Break - On Your Own
Tu1E • Mid-IR Devices and Circuits—Continued

Tu1F • Co-Packaging and Large Photonic Circuits—Continued

Tu1G • Metadevices and High-speed Photonics—Continued

Shanghai

Kairo

Delhi

Tu1E.5 • 10:00
Large-Scale and Fast Optical Circuit Switch Employing Coherent Detection Enabled with Hitless Cascaded-Silicon-Ring-Filter for Local Oscillator (LO) Wavelength Extraction from Laser Bank, Ryosuke Matsumoto1, Ryotaro Konoike1, Katsuhiro Ikeda1, Shu Namiki1, Ken-ichi Sato1; 1National Inst. of Advanced Industria, Japan. We demonstrate a 1,856 x 1,856 optical circuit switch utilizing C-band tuneable local oscillators (LOs) for coherent detection. Hitless and fast (<14.8 us) LO wavelength tuning is realized using a newly fabricated 8-cascaded silicon ring filter having wide free spectrum range (FSR) of >35 nm.

Tu1F.5 • 10:00
Highly Scored
Optically Reconfigurable Ferroelectric Metasurfaces, Artemios Karvounis1, Helena Weigand1, Martin Varga1, Viola Valentina Vogler Neuling1, Rachel Grange1; 1Eidgenossische Technische Hochschule Zurich, Switzerland. We use ferroelectric-plasmonic metasurfaces to demonstrate volatile and non-volatile optical switching of near-infrared light. Plasmonic metasurfaces on lithium niobate enable high-contrast optical switching with ratios up to 2.37:1 (3.7 dB) due to photogalvanic and photorefractive effects, therefore rendering a compact platform for photonic computing.

10:15–10:45 Coffee Break, Exhibition Hall 1

10:45–12:30 Special Workshop: Diversity in Action: Creating a Diverse and Inclusive Workplace, a Place for All to Belong Organisers: Selina Farwell; Lumentum, UK Fatima Gunning; Tyndall National Institute, Ireland Lauren Mecum-Smith; IEEE Photonics Society, USA Marcia Lesky; Optica, USA Allison Romanysyn; SPIE, USA

See page 115 of this programme for more information about this event.

10:45–12:30 Training Course on Integrated Photonic Technologies II Instructors: Hugo Thienpont; Vrije Universiteit Brussel, Belgium Roel Baets; ePIXfab, Belgium Kevin Williams; JePPIX, Belgium Peter O’Brien; Tyndall, Ireland Jurgen Van Erps; Vrije Universiteit Brussel, Belgium

See page 115 of this programme for more information about this event.

12:30–13:30 Lunch Break - On Your Own
Tu3A.1 • 13:30
Single-Mode Fibers with Reduced Cladding and/or Coating Diameters, Pierre Sillard1; Prysmian Group, France. A review of single-mode fibers with reduced cladding and/or coating diameters is presented. Different approaches are compared, and the associated cable miniaturizations and densities are discussed.

Tu3A.2 • 14:00
A 125-µm Cladding Diameter Uncoupled 3-Mode 4-Core Fibre With the Highest Possible Multiplicity Factor, Yuto Sagae1, Takashi Matsui1, Taiji Sakamoto2, Taro Iwaya2, Takayoshi Man1, Takaroni Satô1, Kunimasa Saitô1, Kazuhide Nakajima1; ‘NTT Corporation, Japan; ‘Hokkaido Daigaku, Japan. The highest relative core multiplicity factor of beyond 12 is achieved in a 125 µm cladding diameter uncoupled multi-core fibre by using a common depressed layer design. Feasible inter-core crosstalk below -40 dB/km and effective area over 80 µm² in C-L band are successfully obtained simultaneously.

Tu3A.3 • 14:15
Less Than 0.03 dB Multicore Fiber Passive Fusion Splicing Using New Azimuthal Alignment Algorithm and 3-Electrode Arc-Discharging System, Tristan Kremp1, Yue Liang1, Alan H. McCurdy1; ‘OFS Laboratories, OFS Fite, LLC, USA; ‘OFS Fite, LLC, USA. We present a novel azimuthal alignment algorithm for multicore fiber splicing that separates the core and marker information in side-view images. For two different 4-core fiber designs, average fusion splice losses of less than 0.03 dB are demonstrated using a 3-electrode arc-discharging fusion splicer.

Tu3B.1 • 13:30
Physical Layer Security Management in Optical Networks, Marija Furdek1, Carlos Natalino1; ‘Chalmers Tekniska Högskola, Sweden. As critical communication infrastructure, optical networks must operates securely. However, physical-layer security management faces many theoretical and practical challenges. We focus on the role of machine learning and examine the advantages and pitfalls of exemplary techniques for real-time monitoring of security under evolving threats.

Tu3B.2 • 14:00
High-Speed Self-Reconfiguration and Key Slicing for 100 Gbps Multi-User Hardware Encryptor Have Been Successfully Implemented. The Reconfiguration Time of 16.7 ms With the Encryption Throughput of 160 Gbps Has Been Reported. The Reconfiguration Rate was 676.01 CLB/ms, and the Total System Latency was 817.6 ns., Ekin Arabal1, Romonser Oliverina1, Rui Wang1, Obada Alia1, George Kanellos1, Reza Nejabati1, Dimitra Simeonidou1; ‘Univ. of Bristol, UK. A high-speed self-reconfiguring and key slicing multi-user hardware encryptor for 100 Gbps Ethernet has been implemented successfully. The reconfiguration time of 16.7 ms with the encryption throughput of 160 Gbps has been reported. The reconfiguration rate was 676.01 CLB/ms, and the total system latency was 817.6 ns.

Tu3B.3 • 14:15
Experimental Demonstration of Correlation Between Co-propagating Quantum and Classical Bits for Quantum Wrapper Networking, Sandeep Kumar Singh1, Mehmet Berkay On1, Roberto Proietti1, Gregory S. Kanter3, Prem Kumar1, S. J. Ben Yoo1; ‘Univ. of California Davis, USA; ‘Northwestern Univ., USA; ‘Politecnico di Torino, Italy. We demonstrate the correlation between co-propagating classical and quantum bits for a quantum wrapper networking. The preliminary experiment shows the visibility of > 75% for the quantum bits and the bit error rate < SE-7 for the classical bits.

Tu3C.1 • 13:30
Peta-Scale Embedded Photonics for High Performance Computing, Keren Bergman1; ‘Columbia Univ., USA. High performance data centers are increasingly bottlenecked by the energy and communications costs of interconnection networks. Silicon photonics with comb-driven DWDM links can scale to realize Pb/s chip escape bandwidths with sub-picowatt/bit. We demonstrate how such photonic connectivity in disaggregated architectures accelerates distributed ML applications.

Tu3C.2 • 14:00
New Datacenter Optical Transceivers in the Next Decade, Christopher R. Cole1; ‘II-VI Incorporated, USA. Horizontal line card PCB trace loss, increasing with signaling rate, between pluggable module connector and switch ASIC has threatened this paradigm. Novel vertical front line card architecture saves the front pluggable optics paradigm for another decade, without need for expensive technologies like cable over PCB.

Tu3D.1 • 13:30
Use of Optical Coherent Detection for Environmental Monitoring, Antonio Mecoazzi1, Cristian Antonelli1, Mikael Mazur1, Nicola K. Fontaine1, Haoshuo Chen1, Lauren Dallachiesa1, Roland Ryf1; ‘Nokia Bell Labs, USA; ‘De- partment of Physical and Chemical Sciences, Università degli Studi dell’Aquila, Italy. We discuss the use of the full transmission matrix extracted from a standard coherent receiver to improve the environmental sensing capabilities of optical fiber links.

Tu3D.2 • 14:00
Nonlinearity Tolerance of Tukey Signalling With Direct Detection, Amir Tadbishi1, Frank R. Kschischang1; ‘Univ. of Toronto, Canada. We consider Tukey signalling with 50% duty-cycle between ISI-free and ISI-present intervals, and introduce trellis-based codebook design and decoding. The use of an integrate-and-dump detector equips the scheme with a high degree of robustness to nonlinear modulation distortion, making precise waveform shaping unnecessary.

Tu3D.3 • 14:15
Nonlinearity Tolerant Shaping with Sequence Selection, Mohammad Taha Askari1, Lutz Lampe1, Jeebak Mitra1; ‘Huawei Technologies Canada, Canada; ‘The Univ. of British Columbia, Canada. We introduce a new metric for sequence selection to achieve nonlinearity tolerant probabilistic amplitude shaping (PAS). The new metric provides an about 0.5 dB higher effective signal-to-noise ratio for PAS with short-length constant composition distribution matching in a dual-polarized 256QAM transmission over a long-haul fiber link.
### Tu3E.1 • 13:30
**Invited**

**Fully Integrated Silicon Photonic Circuit Technology with Monolithic III-v/Si Lasers and Amplifiers Integrated at the Backside of Advanced Silicon Photonic Wafers, Sylvie Menezo**

With improvements in silicon photonics, using III-v/Si lasers and optical amplifiers has become more attractive. This talk will introduce recent developments in silicon photonic circuit technology. In particular, fully compliant III-v/Si lasers and optical amplifiers are integrated at the backside of advanced silicon photonic wafers. This offers the advantage of improved integration and reduced footprint. We present results from experiments performed using III-v/Si power laser chips and high-speed amplifiers, the output power characteristics of which vary significantly with mesa width. In this study, we investigated the mesa width by simulation, resulting in lower dispersion and a high value of Vπ. BEX layer that contributes to circular beam expansion was introduced. The optimal combination of BEX layer with silicon photonic circuitry is experimentally demonstrated. BEX layer is experimentally measured, and we observed an increase in tolerance for angle and position deviation of up to 2°. The expansion is due to the highly-tolerant free-space parallel optical wireless communication links (FS-OWLs) to increase the robustness for the first time. The expansion of tolerability for angle and position deviation of FS-OWLs is improved by 20% and 18%, respectively.

#### Tu3E.2 • 14:00

**High Power, Circular Beam CW DFB Laser Using BEX Layer, Shoko Yokokawa**

High power, circular beam CW DFB lasers have been a significant challenge due to high output power CW DFB laser with 18°x18° FFP. Experiments demonstrated BEX layer that contributes to circular beam was introduced. The optimal combination of BEX layer with circular beam was investigated by simulation, resulting in lower dispersion and a high value of Vπ. We observed an increase in tolerance for angle and position deviation of up to 2°. The expansion is due to the highly-tolerant free-space parallel optical wireless communication links (FS-OWLs) to increase the robustness for the first time. The expansion of tolerability for angle and position deviation of FS-OWLs is improved by 20% and 18%, respectively.

#### Tu3E.3 • 14:15

**300-m Multimode Fiber Transmission of 106Gbps PAM-4 Using 850nm High-Contrast-Grating Few-Mode VCSELs, Jiaying Wang**

We demonstrate a record 300m OM3 MMF transmission distance of 106 Gbps PAM4-encoded data by 850-nm VCSELs using a high contrast grating to reduce spectral widths, resulting in lower dispersion and a high value of bandwidth-distance product 32Tbps-m.

### Tu3F.1 • 13:30

**Invited**

**New Generation Space Photonic Components and Sub-Systems for High Data Rate Intra and Inter-Satellite Optical Communications, Leonidas Stamoulidis**

The presentation will outline the state of art and the development of next generation EUV High-Na tools with Monolithic III-v/Si Lasers and Amplifiers Integrated at the Backside of Advanced Silicon Photonic Wafers, Sylvie Menezo; ‘SCINTIL Photonics, France. Abstract not available.

#### Tu3F.2 • 14:00

**Block Interleaver Dimensioning and Real-Time Demonstration for Ground-to-Satellite Optical Communications, Daniel Romero**

This talk will introduce recent developments in high-speed communication using block interleaver (BI) systems. We will present a methodology to dimension the interleaver duration for free-space optical links. We validate it on an FPGA transceiver by emulating ground-geostationary strong turbulence conditions. 150ms interleaver reduces launch power by two orders of magnitude, making it compliant with commercially-available amplifiers to transmit 10Gbit/s.

#### Tu3F.3 • 14:15

**Highly-Tolerant Free-Space Parallel Optical Wireless Communication Links with Signal-to-Signal SNR Difference Compensation, Hidenori Takahashi**

A signal-to-signal SNR difference compensation scheme is demonstrated at 4-parallel free space optical wireless communication links (FS-OWLs) to increase the robustness for the first time. The expansions of tolerability for angle and position deviation of FS-OWLs are improved by 20% and 18%, respectively.

### Tu3G.1 • 13:30

**Invited**

**EUV Lithography: A Role in Photonics? A Deeper Insight in the EUV Exposure Tools, Jan van Schoot**

EUV Lithography plays a key role in following Moore’s Law by decreasing wavelengths and increasing Numerical Aperture (NA). The presentation will outline the state of art and the development of next generation EUV High-Na tools (lambda=13.5nm, 0.55NA) and its potential application in photonics.

#### Tu3G.2 • 14:00

**The State of the Art and Challenges of Silicon Photonics Today, Michal Lipson**

We are now experiencing a revolution in optical technologies, where one can print and control massive optical circuits, on a microelectronic chip. This revolution is enabling a whole range of applications that are in need for scalable optical technologies and its opening the door to areas that only a decade ago were unimaginable.

### Tu3H.1 • 13:30

**Invited**

**Novel Photonic Platforms and Sources II, Anna Fontcuberta I Morral**

As networks achieve increasing performance and scale, they push the boundaries of technology and face greater challenges to continued evolution. The IEEE International Network Generation Roadmap (INGR) is part of the IEEE Future Networks Initiative and was formed to roadmap wireless networks out to a 10 year horizon. Recently, the INGR was expanded to include optical networks. This symposium will present the first edition of the INGR Optics Roadmap, which include x-haul networks, high speed access and indoor networks, and AI in optical networks, among other areas. This symposium will highlighting key elements of the roadmap and look toward potential new areas in which to develop roadmaps. The broader optical networks community is invited to learn about and comment on the roadmap at this event.

See page 17 of this programme for a list of speakers and topics for this Symposium.
Tu3A.4 • 14:30 Experimental Investigation of Coupling Offset Tolerances in a Space-Division Multiplexed 15-Mode Fiber Transmission System, Georg Rademacher, Ruben S. Luis, Benjamin J. Puttnam, Nicolas K. Fontaine, Mikael Mazur, Haohtuo Chen, Roland Ryt, David T. Neilson, Pierre Sillard, Frank Achten, Toshinari Aways; Hideaki Furukawa; National Inst of Information & Comm Tech, Japan; Nokia Bell Labs, USA; Prysmian Group, France; Prysmian Group, Netherlands. We investigate the coupling offset tolerances of a space-division multiplexed 15-mode fiber transmission system. Alignment offset of up to 6 micrometers can lower the Q-Factor by 6 dB for 16-QAM signals. Increased mode-dependent loss is identified as a key origin of the observed signal quality degradation.

Tu3A.5 • 14:45 Commercial Opportunities and Future Roadmap for Hollow Core Fibres, Russell Ellis, Mike Fak, A. Salojohi, S.R. Sandogchii, Hesham Sakr, Thomas Bradley, J. Hayes, Gregory Jasion, E. Numkarn Fokoua, David Richardson, Francesco Paletti, Lumenity Ltd., UK; Optoelectronics Research Centre (ORC), Univ. of Southampton, UK. Nested Anti-Resonant Nodeless Fibre (NANF) technology is achieving record attenuation values for hollowcore, near parity with single-mode fibre. We report the development of hollowcore capable of realising latency saving far beyond other cable types and the potential to redefine the capabilities of future optical networks.

Tu3A.6 • 15:00 Surveillance of Metropolitan Anthropic Activities by WDM 10G Optical Data Channels, Rudi Bratovich, Francisco Martinez Rodriguez, Stefano Strauli, Emanuele E. Virgiliito, Andrea Castoldi, Andrea D’Amico, Francesco Aquilino, Rosanna Pastorelli, Vittorio Curni; Politecnico di Torino, Italy; 5M-Optics, Italy; Links Foundation, Italy. We propose and experimentally verify the detection via 10G channels of SOP temporal variations induced by anthropic activities. Data acquired from a metropolitan optical cable show the effective application of the proposed technique in monitoring and classifying road traffic.

Tu3B.4 • 14:30 An Experimental Demonstration of Secure OFDM-PONs Using Multi-Band Chaotic Non-Orthogonal Matrix-Based Encryption, Peiji Song, Zhouyi Hu; Chun-Kit Chan; Department of Information Engineering, The Chinese Univ. of Hong Kong, Hong Kong; Aston Inst. of Photonic Technologies, Aston Univ., UK. We propose and experimentally demonstrate a novel multi-band CNOM-based encryption scheme for secure OFDM-PONs. The proposed method can achieve a huge key space of $9^{14}$, and reduce the computational complexity by up to 97% of the original single-band encryption without affecting the transmission performance.

Tu3B.5 • 14:45 Confidentiality-Preserving Machine Learning Scheme to Detect Soft-Failures in Optical Communication Networks, Mosés Felipe, Alessandro Pacini, Andrea Sgambelluri, Francesco Paolucci, Luca Valcarenghi; Los Alamos National Laboratory, USA; TecIP Inst., Scuola Superiore Sant’Anna, Italy; CNIT, Italy. We introduce a third-party confidentiality-preserving machine learning scheme for soft-failure detection leveraging the robustness of the principal components algorithm to the changes in the rotation of the data axis. We demonstrate that random scrambling of the data is effective to hide sensitive telemetry information.

Tu3B.6 • 15:00 Surveillance of Metropolitan Anthropic Activities by WDM 10G Optical Data Channels, Rudi Bratovich, Francisco Martinez Rodriguez, Stefano Strauli, Emanuele E. Virgiliito, Andrea Castoldi, Andrea D’Amico, Francesco Aquilino, Rosanna Pastorelli, Vittorio Curni; Politecnico di Torino, Italy; 5M-Optics, Italy; Links Foundation, Italy. We propose and experimentally verify the detection via 10G channels of SOP temporal variations induced by anthropic activities. Data acquired from a metropolitan optical cable show the effective application of the proposed technique in monitoring and classifying road traffic.

Tu3C.3 • 14:30 Nonlinear Pre-Distortion Through a Multi-Rate End-to-End Learning Approach Over VCSER-MMF IM-DD Optical Links, Leonardo Minelli, Fabrizio Forghieri, Roberto Gaudino; Politecnico di Torino, Italy; Cisco Photonics, Italy. We experimentally demonstrate a nonlinear digital pre-distorter for PAM-M shaping in VCSEL+MMF IM-DD links able to operate at a generic baud rate using a fractional sample-per-symbol Neural Network. We focus on efficient and practical multi-rate operation, signal amplitude constraints, and linear equalizer at the receiver.

Tu3C.4 • 14:45 800Gbps PAM4 Transmission Over 10km SSMF Enabled by Low-Complex Duobinary Neural Network Equalization, Christian Blummi, Bo Lü, Bing Lü, Talha Rahman, Md Sabbir Bin Hossain, Maximilian Schaedler, Ulf Schlötmann, Maxim Kuschnerov, Stefano Calabò, Huawei Technologies, Germany; Chair for Electronic Design Automation, Technical Univ. Munich, Germany. On 10km 200Gbps per lane IM/DD PAM4 CWDM4 O-band measurements, neural network equalization meets Volterra equalization performance with 30% less hardware multiplier complexity. Key enabler against strong CD penalties at these reaches/rates is duobinary training.

Tu3C.5 • 15:00 Optimal and Low Complexity Control of SOA-Based Optical Switching with Particle Swarm Optimisation, Hadi Alkharsan, Christopher Parsonson, Zacharaya Shabaka, Xin Mu, Alessandro Ottino-James, Georgios Zervas; Univ. College London, UK. We propose a reliable, low-complexity particle swarm optimisation (PSO) approach to control semiconductor optical amplifier (SOA)-based switches. We experimentally demonstrate less than 610 ps off-on switching (settling) time and less than 2.2% overshoot with 20x lower sampling rate and 8x reduced DAC resolution.
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<td><strong>Tu3E • Lasers for Silicon Photonics and Sensing—Continued</strong></td>
<td><strong>Tu3F • Satellite Based Optical Freespace Communication I—Continued</strong></td>
<td><strong>Tu3G • Novel Photonic Platforms and Sources II—Continued</strong></td>
<td><strong>Tu3H • IEEE International Network Generations Optics Roadmap, 1st Edition—Continued</strong></td>
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<td><strong>Tu3E.4 • 14:30</strong> Lithium-Niobate-Based Frequency-Agile Integrated Lasers, Viacheslav Snigirev1, Aminna Reidhausen2, Grigori Lukachev3, Johann Remensberger1, Rui N. Wang1, Charles Möhl1, Mikhail Churkin1, Anat Siddharth1, Guanhao Huang2, Youri Popoff3, Ute Drechsler1, Daniela Caimi1, Simon Höfl1, Junqiu Liu1, Paul Seidler1, Tobias Kippenberg1; EPFL, Switzerland; 1Eidgenössische Technische Hochschule Zurich, Switzerland; 2IBM Research Europe, Switzerland. We demonstrate narrow-linewidth ultrafast tunable integrated lasers based on heterogeneously integrated thin-film lithium niobate on ultra-low-loss silicon nitride integrated photonic circuits. Using self-injection locking of a hybrid microresonator, we achieve a tuning speed of &gt;10 peta-Hertz-per-second. We also perform FMCW LiDAR ranging experiments.</td>
<td><strong>Tu3F.4 • 14:30</strong> On the Mitigation of Doppler Shift for High-Capacity Coherent FSO Satellite-to-Earth Links, Marco A. Fernandes1, Paulo P. Monteiro1, Fernando Guiomar1; Instituto de Telecomunicações de Aveiro, Portugal. We experimentally assess the impact of the Doppler effect on coherent FSO satellite-to-earth links. Employing probabilistic shaping modulation with adaptive symbol-rate, we demonstrate a significant reliability enhancement for a 600G transmission scenario.</td>
<td><strong>Tu3G.3 • 15:00</strong> Real-Time Transition Dynamics of Harmonically Mode-Locked Femtosecond Ultralong Ring Fiber Lasers, Inês Cáceres Pablo1,2, Juan Diego Ana Castañón1,2; Instituto de Optica Daza de Valdes, Spain; 1Consejo Superior de Investigaciones Científicas, Spain. The transition dynamics between harmonic mode-locking states in Raman-assisted ultralong ring fiber lasers are experimentally studied. The results confirm the expected solitonic behaviour associated to the quasi-lossless extended cavity, but also showcase unusual intermediate states that could inform system design for tunable operation.</td>
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<td><strong>Tu3E.5 • 14:45</strong> Beam-Curvature-Compensated Solid-State Beam Scanner Integrated with Multi-Grating Pitch Tunable Slow-Light VCSELs for Enhanced Field of View, Ruixiao Li1, Xiaodong Gu1, Satoshi Shinada1, Fuminori Koyama1, Tokyo Kogyo Daigaku - Suzukakedai Gakuen, Japan; 1Ambition Photonics Inc., Japan; 1Kokuritsu Kenkyu Kaihatsu Hojin, Japan. We realized 1D solid-state VCSEL beam scanner with field of view (FOV) of &gt;24°x15° integrating tunable VCSELs of different surface gratings pitches. We also compensated the curvature of output fan beam by introducing curved prism mirror. The FOV was expanded to &gt;64°x14° with DOE.</td>
<td><strong>Tu3F.5 • 14:45</strong> Towards Fully Integrated Longwave Infrared Heterodyne Detector Based on Quantum Cascade Technology, Mauro David1, Georg Marschick1, Elena Arigliani1, Nikola Oparčak1, Benedict Schwarz1, Gottfried Strasser1, Borislav Hinkov2; 1TU Wien, Austria. We present the current status of the development of a mid-infrared on-chip heterodyne interferometer, enabled by current advances in quantum cascade technology and plasmonics. We provide the demonstration of high-performance quantum cascade detectors at 9 μm and strategies for on-chip beam combiners onto InP substrates.</td>
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<td><strong>Tu3E.6 • 15:00</strong> Few-Mode Locking in a Photonic Bandgap III-v on Silicon Laser, Pierre Fanneau de La Horde1, Théo Verollet1, Delphine Neel1, Alexandre Shen1, Jean-Guy Provost1, Stephane Malhouitre2, Valentin Ramez1, Karim Hassan3, Jean Decobert1, Joan Ramirez1, Alfredo de Rossi3; Thales SA, France. We demonstrate stable operation of a hybrid microresonator, we achieve a tuning speed of &gt;10 peta-Hertz-per-second. We also perform FMCW LiDAR ranging experiments.</td>
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Tu4A.1 • 15:45
**Invited**
Time-Expansion in Distributed Fibre Optic Sensing, Miguel Gonzalez-Herraez¹, Miguel Soriano-Amat¹, Vicente Duran¹, Hugo F. Martins², Sonia Martin-Lopez³, Maria R. Fernandez-Ruiz⁴; ¹Universidad de Alcala, Spain; ²Universitat Jaume I, Spain; ³Consejo Superior de Investigaciones Científicas, Spain. We review our work on a novel dual-comb technique to achieve a customized temporal expansion of the time-domain trace in a phase-sensitive reflectometer, that allows dynamic interrogation of strain/temperature in optical fibres with high spatial resolution (in the cm range) using only low-bandwidth photodetection (~MHz).

Recent Advances in Submarine Systems: Submarine systems are evolving rapidly, with steadily increasing data capacity and fiber pair counts, and increasing levels of network connectivity complexity. These systems also provide important opportunities for the introduction of new technologies, because each new system is entirely new, without limitation from existing infrastructure. This symposium will invite key stakeholders to provide their view on the most important areas of technology evolution.

See page 18 of this programme for a list of speakers and topics for this Symposium.

Tu4A.2 • 16:15
Improving Earthquake Detection in Fibre-Optic Distributed Acoustic Sensors Using Deep-Learning and Hybrid Datasets, Pablo D. Hernández¹, Marcelo A. Soto¹; ¹Universidad Técnica Federico Santa María, Chile; ²Novelcode SpA, Chile. The capability of fibre-optic distributed acoustic sensing to detect earthquakes is enhanced using deep learning. A training approach combining fibre-optic and traditional seismic measurements is proposed to improve the classification performance of low SNR fibre-based seismic measurements. Results demonstrate up to 98.8% of accuracy.

Tu4C.1 • 15:45
**Invited**
Digital Signal Processing for Next Generation PONs, Amikumar Mahadevan¹; ¹Nokia Bell Labs, USA. DSP is going to play an increasingly important role in enabling future 50G+ PON systems. We focus on techniques drawn from our research that show promise for realizing such next-generation PONs offering higher speeds coupled with the flexibility to adapt to deployment conditions.

Tu4C.2 • 16:15
**Highly Scored**
A Real-Time 25/50/100G Flex-Rate PON Implementation, Vincent Hautsma¹, Dora V. Veen¹; ¹Nokia Bell Labs, USA. Real-time clock, data recovery and equalization of a mixed 25G/50G/100G downstream PON aligned with ITU-T G.9804 standard requirements is shown. 25G is encoded with delay modulation for improved timing recovery under mixed signal modulation.

Tu4D.1 • 15:45
**Tutorial**
Modal Multiplexing and Atmospheric Turbulence Mitigation in Free-Space Optical Communications, Joseph M. Kahn¹, Aniceto Belmonte²; ¹Stanford Univ., USA; ²Technical Univ. of Catalonia, Spain. Spatial-mode multiplexing (SMM) increases free-space optical link capacity, but is impaired by atmospheric turbulence. We derive the optimal modes for SMM links. We review methods for modal (de) multiplexing and MIMO signal processing in SMM links.
This paper introduces the latest trends in the field of optical communications for small satellites and beyond, focusing on the use of SOA-based all-optical photonic integrated devices. The paper discusses the latest developments in the field of optical communications, including the latest trends in the space optical communications for small satellites. The paper introduces the use of SOA-based all-optical photonic integrated devices for small moving platforms and the HICALI project for an optical feedback link from a geostationary Earth Orbit Satellite and ground. We experimentally emulate the OSNR evolution of the SOA-based integrated all-optical neuron with 7-channel WDM input to single output conversion, resulting in a stable output error <0.1 and providing a higher level of noise compression.
Tu4A.3 • 16:30
Distributed Measurement of Rayleigh Backscattered Crosstalk for Bidirectional Multicore Fiber Transmissions Using Multi-Channel Optical Time Domain Reflectometer, Yuto Kobayashi, Tetsuya Hayashi, Takemi Hasegawa, Takahiro Suganuma, Ayumi Inoue, Takuji Nagashima, Hirotaka Sakuma, Takahiro Kikuchi, Osamu Shimakawa, Hidehisa Tazawa, Masato Yoshida, Masataka Nakazawa, Optical Communications Laboratory, Sumitomo Electric Industries Ltd, Japan; Research Inst. of Electrical Communication, Tohoku Univ., Japan. We experimentally demonstrate the in-span nonlinear accumulation of Rayleigh backscattered crosstalk in multicore fibers by novel distributed evaluation technique using multi-channel OTDR, which validates the previously-reported theoretical prediction. We also present the impact of fan-in/fan-out crosstalk on the backscattered crosstalk with experimentally-validated prediction formula.

Tu4A.4 • 16:45
Novel Inter-Core Crosstalk Measurement Method Using Loopback and Bidirectional OTDR Technique, Mayu Nakagawa, Masaki Ohzeki, Katsuhiro Takenaga, Kentaro Ichii, Kabushiki Kaisha Sakura Jigyosho, Japan. We have proposed a novel inter-core crosstalk measurement method using loopback and bidirectional optical time-domain reflectometer (OTDR) technique. In this method, the crosstalk and attenuation can be measured simultaneously. The measured crosstalk using the new and power meter methods has been compared.

Tu4C.4 • 16:45
Cross Gain Modulation Mitigation with Automatic Gain Control of Bidirectional SOA for DSP-Free 50G-PON, Jeremy Potey, Gael Simon, Fabienne Salou, Philippe Chanclo, Mathilde Gay, Laurent Bramerie, Monique Thual, Hélène Debreges, Elena Duran, Natalia Dubrovina, Orange, France; Fonctions Optiques pour les Technologies de l’information, France; Almae Technologies, France. We demonstrate how to mitigate cross gain modulation impairments induced when using a bidirectional SOA shared at OLT side in 50G-PON. Automatic gain control of the SOA reduces by 4 dB the XGM impairments induced by the upstream burst on the downstream signal.

Tu4C.3 • 16:30
Real-Time 100Gb/s Downstream PAM4 PON Link With 34 dB Power Budget, Giuseppe Canuso, Ivan N. Cano, Derek Nessel, Giuseppe Talli, Roberto Gaudino, Munich Research Centre, Huawei Technologies, Germany; Politecnico di Torino, Italy. We experimentally demonstrate a 34dB PON power budget, exceeding E1 ODN class, in real-time with 100Gb/s PAM4 modulation using an amplified O-Band EML plus receiver-side optical amplification and only low complexity FFE equalization.

Tu4D.2 • 16:45
Invited
High Secret Key Rate CV-QKD Systems Leveraged by Advanced Coherent Detection, Amirhossein Ghazisaeidi, Nokia Bell Labs Labs, France. We review the fundamentals of the continuous-variable quantum key distribution, covering concepts from information theory, quantum optics and cryptography, and then discuss the recent efforts to implement these protocols using optical coherent detection technology.
Tu4E.4 • 16:45
Is There an Ideal Plasmonic Modulator Configuration?, Tobias Blatter1, Yannik Horst1, Wolfgang Heni1, Christos Pappas1, Apostolos Tsakyridis1, George Giamougiannis1, Marco Eppenberger1, Manuel Kohli1, Ueli Koch1, Miltiadis Moralis-Pegios1, Nikos Pleros3; 1ETH Zurich, Switzerland; 2Polariton Technologies AG, Switzerland; 3Aristoteleio Panepistemio Thessalonikes Polytechnike Schole, Greece; 4Aristotle Univ. of Thessaloniki, Greece. Resonant and non-resonant modulator configurations are compared for operation with the lowest drive voltage. The ring-assisted Mach-Zehnder modulator is shown to offer a steep slope in the transfer function while delivering an open eye diagram. This enables 220GBd 2PAM plasmonic modulation with record low 0.5Vp.

Tu4G.3 • 16:30
Photonic Reservoir Computing for Nonlinear Equalization of 64-QAM Signals with a Kramers-Kronig Receiver, Sarah Massaad1, Emmanuel Gooskens1, Sthn Sackesyn1, Joni Dambre2, Peter Bienstman2; 1Ghent Univ. - imec, Belgium. Photonic reservoir computing is a promising processing solution for the equalization of fiber optic communication signals. We simulate the nonlinear equalization of 64 Quadrature-Amplitude Modulated signals using a fully passive space multiplexed reservoir. The system deploys direct detection using the recently proposed Kramers-Kronig receiver.

Tu4F.4 • 16:45
Demonstration of Turbulence-Resilient Self-Homodyne 12-Gbit/s 16-QAM Free-Space Optical Communications Using a Transmitted Pilot Tone, Huibin Zhou4, Runzhou Zhang4, Xinzhou Su4, Yuxiang Duan4, Haoqian Song4, Hao Song4, Kaileng Zou4, Robert Boyd3,2, Moshe Tur1, Alan Willner4; 1Tel Aviv Univ., Israel; 2Univ. of Rochester, USA; 3Univ. of Ottawa, Canada; 4Univ. of Southern California, USA. We experimentally demonstrate a turbulence-resilient 12-Gbit/s 16-QAM FSO link using pilot-assisted self-homodyne (rather than heterodyne) detection. Results show link resilience under 400 random turbulence realizations and up to ~20-dB improvement of optical-to-electrical mixing efficiency compared to conventional LO-based coherent detection.

Tu4G.4 • 16:45
Invited
WDM Based Photonic Neural Network for Multi-Channel Optical Fiber Communications, Chaoran Huang1; 1Chinese Univ. of Hong Kong, Hong Kong. Abstract not available.
Tu4A.5 • 17:00
Measurement of Mode-Coupling Along a Multi-Core Submarine Fiber Cable with a Multi-Channel OTDR, Masato Yoshida1, Yoshihiko Hirooka1, Masataka Nakazawa1, Tetsuya Hayashi1, Takeni Hasegawa2, Kohei Nakamura1, Takano Inoue1; 1Tohoku Univ., Japan; 2Sumitomo Electric Industries, Ltd., Japan; 3NEC Corporation, Japan. We describe the precise distributed measurement of mode-coupling along a cabled 60 km-long 4-core fiber (4CF) for submarine transmission using a multi-channel OTDR. The crosstalk values in the fan-in/out devices and 4CF were evaluated separately with a dynamic range of as high as 85 dB.

Tu4A.6 • 17:15 • Invited
Tweaking the Optical Properties of a Hollow Core Optical Fiber by Changing Core and Cladding Gas Pressures, Natalie V. Wheeler1, Thomas Kelly1, Ian A. Davidson1, Shuichiro Ikimi1, Gregory Jasion1, Austin Taranta1, David Richardson1, Francesco Poletti1, Peter Horak1; 1Univ. of Southampton, UK. We show significant changes in the optical properties of hollow core fibres (HCFs) when different gas pressures are applied in the core and cladding post-fabrication. We explain the impact of this for accurate fibre characterisation and means to exploit this effect in HCF-based gas sensing.

Tu4C.5 • 17:00
SOA Pre-Amplified 200 Gb/s/λ PON Using High-Bandwidth TFLN Modulator, Jie Li1, Xu Zhang1, Ming Luo1, Chao Yang1, Zhixue He1, Xi Xiao1; 1State Key Laboratory of Optical Communication Technologies and Networks, China. We experimentally demonstrate 200/240 Gb/s/λ PAM-4 PON downstream transmission based on high bandwidth thin film lithium niobate modulator and direct detection in O-band. By using SOA and Volterra equalizer at the receiver side, over 29/28 dB power budget is achieved after 20 km SSMF.

17:30–19:00 Tu5 • Joint Poster Session I, Foyer 2nd Floor
19:30–23:00 Gala Dinner, MS Rhystärn, Schifflände Basel, 4051 Basel
Tu4E.5 • 17:00
216 GBd Plasmonic Ferroelectric Modulator Monolithically Integrated on Silicon Nitride, Manuel Kohli1, Daniel Chelladurai1, Andreas Messner1, Yannik Horst1, David Moor1, Joël Winiger1, Tobias Blatter1, Tatiana Buvakova1, Clarissa Convertino1, Felix Eltes1, Michael Zervas3, Yuriy Fedoryshyn3, Ulri Koch1, Juerg Leuthold1; 1Inst. of Electromagnetic Fields (IEF), Eidgenossische Technische Hochschule Zurich, Switzerland, 1Ligentec SA, Switzerland; 1Lumiphase AG, Switzerland. We demonstrate a 216 GBd plasmonic ferroelectric modulator monolithically integrated with a foundry-produced silicon nitride platform. The combination of low-loss waveguiding, nanoscale plasmonics, and strong Pockels coefficients in barium titanate offers a platform for next-generation optical interconnect systems.

Tu4E.6 • 17:15
Highest Performance Open Access Modulators on InP Platform, Y Durvasa Gupta1, Guillaume Binet1, Wouter Diels1, Jo Alexander Heibach1, Jonathan Hogan1, Moritz Baser1, Martin Schell1; Fraunhofer Heinrich Hertz Inst., Germany. High-speed (80 Gbps), low drive-voltage ($\pi V = 0.9 V\text{-cm}$), low insertion loss ($IL = 11 \text{ dB}$) travelling wave electrodes based Mach-Zehnder modulators are presented on an open-access InP platform.

17:30–19:00 Tu5 • Joint Poster Session I, Foyer 2nd Floor
17:30–19:00 Workshop on Photonic Startups and Entrepreneurship
Organisers: Erik Pennings, 7 Pennies Consulting, USA
See page 116 of this programme for more information about this event.

19:30–23:00 Gala Dinner, MS Rhystärn, Schifflände Basel, 4051 Basel
We1A • 08:30  Invited
Challenges in Modelling Wideband Transmission Systems, Andre Richter1, Gabriele di Rosa2, Igor Kolchinov3; 1VPIphotonics, Germany. We discuss fiber link analysis challenges of ultra-wideband WDM transmission systems. Exploring an S+L band system, we demonstrate the importance of accounting for the wavelength dependence of the fiber characteristics, particularly the nonlinear effects.

We1B • 08:30
Comparison of Single-Wavelength and Multi-Wavelength Transponders in a Physical-Layer-Aware Network Planning Study, Jasper Müller1,2,1, Ognjen Jovanovic1,2, Jürg-Peter Elbers2, Carmen Mas-Machuca2, Helmut Griesser3, Tobias Fehnberger2, Carmen Mas-Machuca2, Carmen Mas-Machuca2; 1Chair of Communication Networks, Technische Universität München, Germany; 2DTU Electro, Danmarks Tekniske Universitet, Denmark; 3ADVA Optical Networking SE, Germany. Based on suitable system architectures and realistic specifications, transmit OSNR penalties and spectral constraints of multi-wavelength transponders are identified and analyzed in a network study. We report up to 70% less required lasers at the expense of a slight increase in number of lightpaths.

We1C • 08:30  Invited
GAWBS Noise in Digital Coherent Transmission, Masataka Nakazawa1; 1Tohoku Univ., Japan. Recent research progress on GAWBS noise in single- and multi-core fibers is presented including an analysis of the phase noise spectrum in various optical fibers, the influence of noise on digital coherent transmission, and the noise correlation between cores in four-core fiber.

We1D • 08:30  Tutorial
Subsea Open Cables Designs, Challenges and an Outlook for the Future, Elizabeth Rivera Hartling1; 1Meta Platforms Inc, USA. Subsea Open Cable Designs have become the industry norm, and collaborative efforts to standardize GSNR has provided foundational tools for broad industry adoption. Technology advancements in SDM continue to increase cable capacity potential, and additional forward-looking developments are charting a path towards Petabit cables.
new opportunities and physics might arise, but studies are still very recent. This symposium focuses on the recent development in the design of integrated devices for leveraging both 2nd and 3rd order nonlinear effects. Different material platforms, approaches, potential and applications will be discussed.

See page 18 of this programme for a list of speakers and topics for this Symposium.

We1E.1 • 08:30

Microwave Photonic RF Comb Generator up to 140 GHz, Hendrik Boerma1, Felix Ganzer1, Patrick Runge1, Martin Schell2, Edgar Fernandez2, Benjamin Rudin2, Florian Emann2, ‘Fraunhofer Heinrich-Hertz-Inst., Germany’; ‘Technical Univ. Berlin, Germany’; ‘Menhir Photonics AG, Switzerland’. A microwave photonic RF comb generator for generation of stable radio frequency combs is presented. It combines an fs-pulse laser and a broadband photodetector module. The subsystem generates a pulse with a FWHM of 5.8 ps and generates an RF comb up to 140 GHz.

Integrated nonlinear optics is a highly active research area. The investigations and study of nonlinear effects based on third-order nonlinearity, which is ubiquitous to all material platform through their third order susceptibility $\chi^{(3)}$, is the most developed and now transitioning to proof-of-concept experimental applications.

Unlike the widely accessible Kerr effect, second-order nonlinear effects are only intrinsic to non-centrosymmetric media. However, $\chi^{(2)}$ nonlinearity is essential for the electro-optic effect and underpins various three-wave mixing parametric processes. With the recent maturing in fabrication of integrated waveguides based on materials exhibiting both $\chi^{(2)}$ and $\chi^{(3)}$ nonlinearities (SiC, LNOI, AlN…) new opportunities and physics might arise, but studies are still very recent. This symposium focuses on the recent development in the design of integrated devices for leveraging both 2nd and 3rd order nonlinear effects. Different material platforms, approaches, potential and applications will be discussed.

We1F.2 • 08:45

Highly Scored

10.51-Tbit/s if-Over-Fibre Mobile Fronthaul Link Using SDM/WDM/SCM for Accommodating Ultra High-Density Antennas in Beyond-5G Mobile Communication Systems, Kazuki Tanaka1, Shinya Nemura1, Shota Ishimura2, Kosuke Nishimura1, Ryo Inohara1, Takehiro Tsutsumi1, Masatoshi Suzuki3, ‘KDDI Research, Inc., Japan’. 4608 x 380.16-MHz 64-QAM OFDM signals are transmitted over a 10.1-km uncoupled 12-core fibre by 16-wavelength-division and 24-subcarrier multiplexing, meeting the error vector magnitude criterion of less than 8%. The highest aggregate capacity of 10.51 Tbit/s in IM-DD-based analog radio-over-fibre transmission is experimentally verified.

See page 18 of this programme for a list of speakers and topics for this Symposium.
We1A • Ultra-wideband Optical Systems—Continued

We1A.2 • 09:00
Closed-Form Expressions for the Impact of Stimulated Raman Scattering Beyond 15 THz, Dimitris Usunidis¹, Kostas Nikolau¹, Chris Matrakidis¹, Alexandros Stavdas¹, Andrew Lord³, "OpenLightComm Europe, Czechia; "BT Group Plc, UK. We introduce a closed-from expression which calculates the impact of SRS for channels spaced beyond 15 THz. This formalism is benchmarked against a numerical method in a four-band system with up to 300 channels, showing a maximum error of 0.18 dB in all examined cases.

We1B • Network Planning and Cost Efficiency—Continued

We1B.3 • 09:00
Selective Hybrid EDFA/Raman Amplifier Placement to Avoid Lightpath Degradation in (C+L) Networks, Memedeh Ibrahim³, Giovanni Simone Sticca³, Francesco Musumeci³, Andrea Castoldi³, Rosanna Pastorelli³, Massimo Tomatore³, "Politecnico di Milano, Italy; "SM-Optics, Italy. We investigate optimized placement of hybrid EDFA/Raman amplifiers in (C+L) networks to avoid lightpath degradation due to ISRS. We numerically compute eight strategies for amplifier deployment showing that an optimized placement of Raman amplification can lead to 40% fewer amplifiers compared to baseline deployment practices.

We1C • Digital Optical Fiber Nonlinearity Mitigation—Continued

We1C.2 • 09:00
Towards FPGA Implementation of Neural Network-Based Nonlinearity Mitigation Equalizers in Coherent Optical Transmission Systems, Pedro Jorge J. Freire de Carvalho Souza¹,², Michael Anderson¹, Bernhard Spinelli¹, Thomas Bee¹, Yaroslav Pylypyskij¹, Tobias Eriksson¹, Nelson Costa¹, Wolfgang Schairer¹, Michaela Blott¹, Antonio Napoli¹, Sergei Turystin¹, \"Aston Univ., UK; \"Infineon Corp, Germany; \"Xilinx Inc, Ireland. For the first time, recurrent and feedforward neural network-based equalizers for nonlinearity compensation are implemented in an FPGA, with a level of complexity comparable to that of a dispersion equalizer. We demonstrate that the NN-based equalizers can outperform a 1-step-per-span DBP.

We1D • Subsea Communications—Continued

We1D.2 • 09:30
Multi-Core vs Hollow-Core Fibers: Technical Study of Their Viability in SDM Power-Constraint Submarine Systems, Alexis Barco Meseguer¹, Joao L. De Oliveira Pacheco¹, Jean-Christophe Antona¹, Juliana Tiburcio de Araujo¹, Vincent Letellier¹, \"Alcatel Submarine Networks, France. We study the viability of Multi-core and Hollow-core fibers for submarine links, considering transceiver limitations and typical power constraints of SDM systems. We discuss the challenges that these technologies will face to be adopted in the long term.
We1E • Heterogeneous Integration—Continued

We1E.2 • 09:00
Mid-IR Plasmonics for Monolithic Photonic Integrated Circuits, Bora Hinkov, Florian Pilat, Mauro David, Andreas Schweighofer, Patricia L. Souza, Laurent Lux, Bettina Baugartner, Daniela Ristani, Benedikt Schwarz, Hermann Detz, Aaron M. Andrews, Bernhard Lendl, Gottfried Strasser; TU Wien; Austria; “Lab-Sem-CETUC, Pontificia Universidade Catolica do Rio de Janeiro, Brazil; “Debye Inst. for Nanomaterials Science, Universiteit Utrecht, Netherlands; “CEITEC, Brno Inst. of Technology, Czechia. We present a monolithic mid-infrared lab-on-a-chip for sensitive and selective real-time spectroscopy of liquids. Beyond state-of-the-art operation of our fingertip-sized sensor devices is demonstrated by in-situ reaction monitoring experiments of thermally-induced protein-conformational changes and by dynamical residual-water analysis in a solvent.

We1F • MW Photonics and Lidar—Continued

We1F.3 • 09:00
Frequency-Selective Phase Noise Cancellation in Photonics-Based Radio Frequency Multiplication up to W-Band, Antonio Malacarne, Antonio D’Errico, Alessandra Bigongiari, Antonella Bogoni, Marco Secondini; “Scuola Superiore Sant’Anna, Italy; “Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Italy; “Ericsson Research, Italy. In the case of photonics-based radio frequency multiplication, a method for cancelling the phase noise of the generated carrier at adjustable periodic frequency offset values is proposed, theoretically analyzed, and experimentally demonstrated up to 110 GHz frequency generation from sixfold 18.3 GHz multiplication.

We1G • Nonlinear Optics in $\chi^{(2)}/\chi^{(3)}$ Integrated Photonics—Continued

We1H • 8th International Symposium for Optical Interconnect in Data Centres I—Continued

We1E.3 • 09:15
Uncooled 100-GBaud Operation of Directly Modulated Membrane Lasers on High-Thermal-Conductivity SiC Substrate, Suguru Yamaoka, Nikolaos P. Diamantopoulos, Hidetaka Nishi, Takuro Fujii, Koji Takeda, Tatsuruo Hiraki, Shigeru Kanazawa, Takaaki Kikitsuka, Shinji Matsuo; NTT Device Technology Labs, Japan; NTT Device Innovation Center, Japan. We have developed directly modulated membrane lasers on a high-thermal-conductivity SiC substrate, which exhibit bandwidth of >110 GHz at 25°C, and 74 GHz at 85°C by large relaxation oscillation frequency and optical feedback effect. We demonstrate 2-km transmission of 100-Gbit/s NRZ signals with uncooled operation.

We1F.4 • 09:15
Invited
State of the Art in Silicon Photonics Integrated Circuits for Lidar, Jonathan Doylend; Intel Corporation, USA. Silicon photonics offers a means of transistorizing complex bulk optical systems into a photonic integrated circuit. This talk will review some of the key challenges and approaches to Lidar, and discuss how silicon photonics can address them.

We1E.4 • 09:30
Highly Scored
Micro-Transfer-Printed Membrane DR Lasers on Si Waveguide Modulated With 50-Gbit/s NRZ Signal, Yoshiho Maeda, Takuro Fujii, Takuma Aihara, Tatsuruo Hiraki, Koji Takeda, Tai Tsuchizawa, Hiroki Sugiyama, Tomonori Sato, Toru Segawa, Yasutomo Ota, Satoshi Iwamoto, Yasuhiko Arakawa, Shinji Matsuo; NTT Device Technology Labs, NTT Corporation, Japan; “Inst. for Nano Quantum Information Electronics, The Univ. of Tokyo, Japan; “Department of Applied Physics and Physico-Informatics, Keio Univ., Japan; “Inst. of Industrial Science, The Univ. of Tokyo, Japan. We fabricate directly modulated membrane distributed reflector lasers on a Si waveguide by using the micro-transfer printing. A low threshold current of 1.2 mA and good optical coupling between the laser output and 220-nm-thick Si waveguides are achieved. 50-Gbit/s NRZ signal modulation was also demonstrated.
Multifiber vs. Ultra-Wideband Upgrade: A Techno-Economic Comparison for Elastic Optical Backbone Network, Rana K. Jana, Md A. Iqbal, Neil Parkin, Anand Srivastava, Arvind Mishra, Jitendra Balakrishnan, Phillip Coppin, Andrew Lord, Abhijit Mitra. 1; BT Group Plc, UK; 2; Sterlite Technologies Ltd, India; 3; Indraprastha Inst. of Information Technology Delhi, India. We report the evolution of cost-per-bit with the growth of core optical network traffic while comparing multifiber and ultra-wideband solutions. Results show that ultra-wideband systems can save 30% of the total cost while using 22.2% less upgrades than multifiber C band system.

Deep Convolutional Recurrent Neural Network for Fiber Nonlinearity Compensation, Prasham Jain, Lutz Lampe, Jeebak Mitra. 1; Univ. of British Columbia, Canada; 2; Huawei Technologies Canada, Canada. An iterative deep convolutional recurrent neural network is proposed to mitigate fiber nonlinearity with distributed compensation of polarization mode dispersion, demonstrating 1.3 dB Q-factor gain over previous neural network-based techniques for dual-polarized 960 km 32 Gbaud 64QAM transmission.

Learned Digital Back-Propagation for Dual-Polarization Dispersion Managed Systems, Mohannad Abu-Romoh, Nelson Costa, Antonio Napolitano, Bernhard Spinnler, Yves Joaouen, Mansoor Yousefi. 1; Telecom ParisTech, France; 2; Infinera G, Germany; 3; Infinera, Portugal. Digital back-propagation (DBP) and learned DBP (LDBP) are proposed for nonlinearity mitigation in WDM dual-polarization dispersion-managed systems. LDBP achieves Q-factor improvement of 1.8 dB and 1.2 dB, respectively, over linear equalization and a variant of DBP adapted to DM systems.
We1E.5 • 09:45 ***invited***
Photonic Neural Networks for Analog-Digital Processing, Thomas Ferreira de Lima \(1\); NEC Laboratories America, USA. Neural networks have recently showcased state-of-the-art performance in signal processing applications. However, real-time demonstrations for high bandwidth signals require integrating analog computing hardware, such as photonics, to digital processors. In this talk, we will show examples of analog time series processing with photonic processors.

We1F.5 • 09:45
FM-CW LiDAR for Proximity Sensing Applications Integrating an Alignment-Tolerant FSO Data Channel, Aina Val Martí \(1\), Thomas Zemen \(1\), Bernhard Schenk \(1\); AIT Austrian Inst. of Technology, Austria. We experimentally demonstrate the integration of a 1.25 Gb/s FSO data channel in a FM-CW LiDAR and evaluate the sensing vs. comms performance trade-off when making the data channel robust to receiver misalignment through an expanded, fan-shaped LiDAR beam.

We1F.6 • 10:00
Photonics-Aided THz-Wireless Transmission Over 4.6 km Free Space by Plano-Convex Lenses, Weiping Li \(1\), Bowen Zhu \(2\), Feng Wang \(1\), Wen Zhou \(1\), Jinguo Yu \(1\), Feng Zhao \(1\), Jianjun Yu \(1\); Fudan Univ., China; \(2\) Beijing Univ. of Posts and Telecommunications, China; \(3\) Xi’an Univ. of Posts and Telecommunications, China. We demonstrate a photonics-aided THz-wireless transmission over 4.6 km free space by plano-convex lenses. The use of plano-convex lenses greatly extends the wireless transmission distance. Advanced digital signal processing (DSP) algorithms improve the spectral efficiency of the system.

10:15–10:45 Coffee Break, Exhibition Hall 1
We2A.1 • 10:45
Amplifier-Free Low-CSPR Polarization-Division-Multiplexing Self-Homodyne Coherent Receiver for ZR Transmission, Ming-Ming Zhang1, Yizhao Chen1, Weihao Li1, Junda Chen1, Tianhao Tong1, Sihe Hu1, Yuqi Li2, Jiajun Zhou1, Zheng Yang1, Ming Tang2; School of Cyber Science and Engineering, Huazhong Univ. of Science and Technology, China; 2School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China. By utilizing the optical injection locking to regenerate remotely delivered LO, an amplifier-free low-CSPR polarization division multiplexing self-homodyne coherent system for ZR standard is proposed and demonstrated. Single polarization 240-Gbps (60GBaud-16QAM) transmission along 75km SMF has been achieved even without CPR algorithms.

We2A.2 • 11:00
Over 90-km 400GBASE-LR8 Repeated Transmission with Bismuth-Doped Fibre Amplifiers, Yuta Wakayama1, Daniel J. Elson1, Vitaly Mikhailov1, Rachata Maneekut1, Jiawei Luo1, Noboru Yoshikane1, Daryl Inniss1, Takehiro Tsuntani1; 1KDDI Research, Japan; 2CPS Laboratories, USA; 3Chulalongkorn Univ. Faculty of Engineering, Thailand. Simple single-stage bismuth-doped fibre amplifiers extend the transmission reach of an emerging 400G transceivers' capability. The 8 LAN-WDM signals are continuously delivered over 90 km without frame loss for more than 7 days.

We2B.1 • 10:45
Invited
Unified SDN Control and Management of the Disaggregated Multi-Vendor IP Over Open Optical Network, Arturo Mayoral1, Jean Francois Bouquier2, José Antonio Gómez2, Renzo Diaz3, Oscar Gonzalez de Dios4, Juan Pedro Fernández-Palacios5, Kadir Coskun6, Riza Bozaci7; 1Telecom Infra Project, USA; 2Vodafone, Spain; 3Telefónica I+D/Global CTO, Spain; 4Telia Company, Sweden; 5Turkcell, Turkey; 6MTN, South Africa; 7Meta Connectivity, UK. The Telecom Infra Project (TIP) MUST and MANTRA operator's sub-groups have agreed a common target SDN architecture to evolve from monolithic/aggregated to multi-vendor disaggregated Open Optical Networks. Enabling also, a new generation of IPoDWDM networks based on IP routers equipped with 400G coherent pluggable transceivers.

We2B.2 • 11:00
Over 90-km 400GBASE-LR8 Repeatered Transmission with Bismuth-Doped Fibre Amplifiers, Yuta Wakayama1, Daniel J. Elson1, Vitaly Mikhailov1, Rachata Maneekut1, Jiawei Luo1, Noboru Yoshikane1, Daryl Inniss1, Takehiro Tsuntani1; 1KDDI Research, Japan; 2CPS Laboratories, USA; 3Chulalongkorn Univ. Faculty of Engineering, Thailand. Simple single-stage bismuth-doped fibre amplifiers extend the transmission reach of an emerging 400G transceivers' capability. The 8 LAN-WDM signals are continuously delivered over 90 km without frame loss for more than 7 days.

We2C.1 • 10:45
Tutorial
End-to-end Learning of Optical Communication Systems: A Beginner's Guide, Christian Häger1; 1Chalmers Tekniska Högskola, Sweden. This tutorial will review communication autoencoders where the main idea is to replace handcrafted transmitter and receiver algorithms with neural networks and jointly optimize them in an end-to-end fashion. We discuss several applications to optical systems including training with multiple users and channel capacity estimation.

We2D.1 • 10:45
Invited
Advanced O-Band Transmission Using Maximum Likelihood Sequence Estimation, Hiroki Taniguchi1, Shuto Yamamoto2, Manasori Nakamura1, Akira Masuda1, Yoshiaki Kisaka1, Shigeru Kanazawa2, Hirota Nakamura3, 1NTT Network Innovation Laboratories, Japan; 2NTT Device Innovation Center, Japan. We discuss advanced maximum likelihood sequence estimation methods for short reach IM-DD transmission, which include reducing complexity of Viterbi algorithm and improving the decoding performance with precise emulation of nonlinear responses in transmission systems. We also present transmission experiments over 200-Gbps/lane using our proposed methods.
We demonstrate a flat comb generator cascading multi-stage phase modulator to an MZM and reusing driving signals. It efficiently broadens bandwidth reducing power consumptions because the MZM for spectral flattening also enhances the bandwidth and driving signals are reused. 37x23-GHz ultra-wideband MZM for spectral flattening also enhances the bandwidth reducing power consumptions because the MZM for spectral flattening also enhances the bandwidth and driving signals are reused. 37x23-GHz ultra-wideband MZM for spectral flattening also enhances the bandwidth reducing power consumptions because the MZM for spectral flattening also enhances the bandwidth and driving signals are reused.
We propose a reach-extended self-homodyne coherent bidirectional transmission for connectivity in national core, metro and aggregation and point-to-multipoint XR optics considering use cases. Experiments making use of 400G ZR pluggable modules are demonstrated with simple maximum-likelihood phase recovery, yielding a cost-efficient solution for future inter-datacentre interconnects.

We present a WDM over SDM system utilizing gain-clamped SOA as both linear-booster signal amplifier and LO regenerator. Successful 400G transmissions over 50-km and 75-km links are demonstrated with simple maximum-likelihood phase recovery, yielding a cost-efficient solution for future inter-datacentre interconnects.

We propose a WDM over SDM system utilizing gain-clamped SOA as both linear-booster signal amplifier and LO regenerator. Successful 400G transmissions over 50-km and 75-km links are demonstrated with simple maximum-likelihood phase recovery, yielding a cost-efficient solution for future inter-datacentre interconnects.
We2E.3 • 11:15
InP/Si₃N₄ Dual-Laser Hybrid Source-Based Wireless Mm-Wave Communication Link Using Optical Injection Locking, Robinson C. Guzman¹, Univ. Carlos III Madrid, Spain. This paper presents an InP/Si₃N₄-based dual-laser hybrid optical source stabilized using an optical injection locking for the mm-wave signal generation which provides a carrier frequency at 93 GHz for a wireless communication link. We demonstrate a wireless link with a data rate up to 28 Gbps.

We2F.2 • 11:15
Highly Scored
Demonstration of 32-Gbit/s Terahertz-Wave Signal Transmission Over 400-m Wireless Distance, Junjie Ding¹, Weiping Li¹, Yanyi Wang¹, Feng Wang¹, Bowen Zhu¹, Mingxu Wang¹, Yi Wei¹, Wen Zhou¹, Jiao Zhang¹, Min Zhu¹, Jianguo Yu¹, Feng Zhao¹, Jianjun Yu¹,²;¹ Fudan Univ., China;²Purple Mountain Laboratories, China;³Beijing Univ. of Posts and Telecommunications, China;⁴Xi’an Univ. of Posts and Telecommunications, China. In a photonics-aided THz-wave communication system, we achieve an experimental demonstration of a record-breaking 400-m wireless distance at 335 GHz by using PTFE lenses and advanced DSP algorithms.

We2E.4 • 11:30
InP/Si₃N₄ Hybrid External-Cavity Laser With sub-kHz Linewidth Acting as a Pump Source for Kerr Frequency Combs, Pascal Maier¹,², Yung Chen¹, Yilin Xu¹,², Matthias Bläicher¹,², Dimitri Geskus¹, Ronald Dekker¹,², Junru Liu¹, Philipp-Immanuel Dietrich¹,², Huanta Peng¹, Sebastian Randel¹, Wolfgang Freude¹, Tobias Kippenberg¹, Christian Koos¹,²,¹ Inst. of Photonics and Quantum Electronics (IPQ), Karlsruhe Institut fur Technologie, Germany;²Inst. of Microstructure Technology (IMT), Karlsruhe Institut fur Technologie, Germany;³LioniX International BV, Netherlands;⁴Ecole Polytechnique Federale de Lausanne, Switzerland;⁵Deeplight SA, Switzerland. We report on an InP/Si₃N₄ hybrid integrated ECL that relies on 3D-printed coupling elements such as intra-cavity photonic wire bonds and facet-attached microlenses. We demonstrate 90nm tuning range, SMSR above 60dB, and intrinsic linewidths of 979Hz. We use the ECL as tunable pump laser for Kerr-comb generation.

We2F.3 • 11:30
127.8 Gb/s OFDM-PDM-PS256QAM W-Band Signal Delivery Over 10 km SMF-28 and 4.6 km Wireless Distance, Weiping Li¹, Yuxuan Tan¹, Bowen Zhu¹, Feng Wang¹, Yanyi Wang¹, Junjie Ding¹, Kaihui Wang¹, Li Zhao¹, Wen Zhou¹, Jianguo Yu²;¹ Fudan Univ., China;²Beijing Univ. of Posts and Telecommunications, China;³Xi’an Univ. of Posts and Telecommunications, China. We experimentally demonstrated a record-breaking delivery of 127.8 Gb/s OFDM-PDM-PS-256QAM signal over 10 km SMF-28 fiber and 4.6 km wireless distance at W-band, employing polarization multiplexing technology and advanced DSP algorithms.
We show that variation of the optical path control scheme with AMCC Telemetry, Hiroshi Ou, Kota Asaka, Tatsuya Shimada, Tomoaki Yoshida; NTT, Japan. To ensure stringent SLA requirements in the 5G/6G era, we propose and demonstrate real-time performance collection, analysis and control of optical path scheme based on commercial and open-source products. We verified that the automatic optical path control can perform the aforementioned tasks within 20 milliseconds.

The QAMeleon project is developing novel, ultra-fast and energy efficient sliceable transceivers and WSS switches aiming to address the stringent demands of future metro/core and DCI networks. A summary of the latest results acquired from the aforementioned tasks within 20 milliseconds.

The bipolar constellations gain up to 1.8 dB over their IM (IM) when using an oversampled direct detection receiver. The bipolar constellations gain up to 1.8 dB over their IM counterparts.
Coherent Expansion of a Gain-Switched Optical Frequency Comb Employing a Dual-Stage Active Demultiplexer, Prajwal Doddaballapura Lakshmijayasimh, Alexander Kaszubowska-Anandarajah, Eamonn P. Martin, Manas Srivastava, Syed Tazamul Ahmad, Prince Anandarajah; The Photonic Systems and Sensing Lab., Dublin City Univ., Ireland; CONNECT Research Centre, The Univ. of Dublin Trinity College, Ireland. We experimentally demonstrate a novel expansion architecture for a gain-switched laser, based on simultaneous injection-locking of multiple modes of a gain-switched Fabry-Perot laser, using a dual-stage active demultiplexer. A 6.25 GHz expanded comb with a spectral bandwidth over 875 GHz (expansion factor ~10) is presented.

We demonstrate the first practical real-time dual-channel fiber-THz-fiber 2 × 2 MIMO seamless integration system with a record net data rate of 2 × 103.125 Gb/s at 385 GHz and 435 GHz over two spans of 20 km SSMF and 3 m wireless link.

We have been developing various types of scalable programmable photonic processors based on a silicon photonic MEMS platform with direct application to classical and quantum photonics. The platform enables the implementation of large-scale circuits by enabling ultra-low-power operation and low optical loss.

We experimentally demonstrate, for the first-time to our knowledge, reconfigurable radiofrequency signal processing in a few-mode fiber link. The modes of the double-clad step-index few-mode fiber exhibit relatively constant incremental chromatic dispersion values, enabling its operation as a tunable 2D sampled true-time delay line.
We2C.4 • 12:15
Phase Retrieval Receiver Based on Deep Learning for Minimum-Phase Signal Recovery, Daniele Orsuti1, Cristian Antonelli2, Alessandro Chiuso1, Marco Santagiustina1, Antonio Mecozzi2, Andrea Galtarossa1, Luca Palmieri1;
1Dipartimento di Ingegneria Dell’Informazione, Universita degli Studi di Padova Dipartimento di Ingegneria Dell’Informazione, Italy; 2Dipartimento di Scienze Fisiche e Chimiche, Universita degli Studi dell’Aquila Dipartimento di Scienze Fisiche e Chimiche, Italy. We propose a deep learning-based phase retrieval receiver for minimum-phase signal recovery. Simulation results show that the HD-FEC limit at BER 3.8e-3 is achieved with 2-dB lower CSPR and 1.6-dB better receiver sensitivity compared to a conventional four-fold upsampled Kramers-Kronig receiver in relevant system settings.

12:30–13:30 Lunch Break - On Your Own
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**We2F.6 • 12:15**  
End-to-End Demonstration of an SDN-Reconfigurable, FPGA-Based TxRx Interface for Analog-IFoF/MmWave X-Haul, Konstantina Kanta, Panagiotis Tournass, Giannis Giannoulis, Ioannis Stratakos, George Lentaris, Elisaios-Alexios Papatheofanous, Ioanna Mesogiti, Eleni Theodoropoulou, Aristotelis Maranga, Dimitris Synvelis, Evrydiki Kyriazi, George Breostas, Kostas Tokas, Nikos Argiris, Chris Vagianas, Bonis Maximidis, Paraskevas Bakopoulos, Agapi Mesodiakaki, Marios Gkatianas, Georgios Kallas, Kostas Tsagkaris, Nikos Piers, Dionysios Reiss, George Lyberopoulos, Dimitrios Apostolopoulos, Dimitrios Soudris, Hercules Avramopoulos, ICN/NTUA, Greece; 'Electronics Laboratory, Department of Physics, NKUA, Greece; 2Cosmote Mobile Telecommunications SA, Greece; 3Department of Informatics, Aristotle University of Thessaloniki, Greece; 4Inelligent PC, Greece.  
We present an E2E analog X-haul deployment demonstrator, based on successful integration of an SDN-reconfigurable, FPGA-based A-IFoF TxRx into MNO's infrastructure, relying on constant traffic monitoring and real-time adaptation of the TxRx capacity, showcasing concurrent services support (AR/VR, IoT, 4K video streaming) over A-IFoF/mmWave transport implementation.

| 12:30–13:30 Lunch Break - On Your Own |
Multimode fibers support symbol demapping.

A simple one-step Fourier Neural Operator.

Fiber Optic Communications Research Center, Graduate School of Engineering, Osaka Univ., Singapore.

Politecnico di Torino, Italy; NTT Network Innovation Laboratories, Huawei Munich Research Center, Germany.

We demonstrate 1,2 Nihon Denki Kabushiki Kaisha, Japan; Fujitsu Technische Universität Darmstadt, Germany.

We show that even the anomaly loss on transmission performance in systems with hybrid EDFA/Raman amplification and propose the implementation of a nonlinear demapper for coherent transceivers and use Lipschitz constraints to increase robustness against device variations. Offline experiments demonstrate that for 64QAM we can recover the performance of a digital implementation.

Transmission of 160.7-GBaud 1.64-Tbps Signal Using Phase-Interleave-Lasing Optical Modulator and Digital Spectral Weaver, Hiroshi Yamazaki1,2, Yoshihiro Ogiso1, Masanori Nakamura1, Tetsuro Jyo2, Hiroshi Hashimoto2, Josuke Ozaki2, Takayuki Kobayashi2, Toshikazu Hashimoto1,2, Yoshihiro Ogiso1,2, Munehiko Nakatani1,2, Robert Maher,1 Infineera Corporation, USA.

The performance of a commercially available vertically integrated 100Gbps PCS-64QAM digital coherent MODEM is reviewed. Record transmission reach for real-time 1.6Tbps (2x800G) super-channels in a fully loaded C- and L-band transmission system is demonstrated.

We propose a Fourier Neural Operator based fibre channel modelling method with both time-domain and frequency-domain operators. The proposed method performs a high accuracy in the WDM long-haul transmission system.

DFE State-Tracking Demapper for Soft-Input FEC in 800G Data Center Interconnects, Kaiquan Wu1,2, Gabriele Liguori1, Jeffrey Lee1, Lotte M. Paulissen2, Qunbi Zhuge1, Paparao Palacharla1, Andrea D’Amico1,2, Magnus Karlsson3,4, Olga Vassilieva1,2, Maximilian Wimmer1, Robert Maher,1 Infineera Corporation, USA.

We consider the use of DFE error propagation state model is used to track the DFE error propagation for 4-PAM. The knowledge of DFE output states is used to provide better impairment mitigation than equalizing output power for normally problematic in multidimensional MLC, is reduced, which enables high-throughput implementation.

Power-Efficient and Robust Nonlinear Demapper for 64QAM Using in-Memory Computing, Arnon Eldesbiny1, Georg Böcherer1, Grace Li Zhang2, Bing Li1, Maximilian Schaadler1, Stefano Calabrò1,2, Lill Schlüchtmann1, Technische Universität Darmstadt, Germany; Huawei Munich Research Center, Germany.

In-memory computing can trade computational accuracy for power saving. We consider the implementation of a nonlinear demapper for coherent optical transceivers and use Lipschitz constraints to increase robustness against device variations. Offline experiments demonstrate that for 64QAM we can recover the performance of a digital implementation.

We3B.3 • 14:00
Mitigation of Anomaly Loss in Optical Transmission System with Hybrid EDFA/Raman Amplification, In-woong Kim1, Olsa Vassilieva1, Paparo Palacharla1, Fujitsu Network Communications, USA.

We analyse impact of anomaly loss on transmission performance in systems with hybrid EDFA/Raman amplification and propose two mitigation techniques to minimize the impairment. We demonstrate that equalizing SNRdem provides better impairment mitigation than equalizing output power for the affected span in transmission link.
We3E • Passive Photonic Functions

Presider: Dan Marom; Hebrew Univ. of Jerusalem, Israel

Wednesday, 21 September 13:30–15:15

- Compact, Spatial-Mode-Interaction-Free, Ultra-Loss, Nonlinear Photonic Integrated Circuits, Xinru Ji, Junqiu Liu, Jiu He, Rui N. Wang, Zhen Gui, Johann Riemensberger, Tobias Kippenberg; École Polytechnique Fédérale de Lausanne, Switzerland. We implement Euler bends to build compact high-Q racetrack microresonators, featuring a small footprint of only 0.21mm² for 19.8 GHz FSR. We demonstrate that these multi-mode microresonators can be operated in the single-mode regime and generate a single soliton microcomb.

- Between a power penalty. PEGs. Experimental results show 2dB insertion loss, -35dB Planar Echelle Grating (PEG) and eight 1×5 800GHz demonstrate a photonic integrated 1×40 100GHz spaced photonic chip. Based on Cascaded Planar Echelle Gratings on 3-μm silicon technology, we demonstrate that these multi-mode microresonators can be operated in the single-mode regime and generate a single soliton microcomb.

- Secure and robust optical networks are key for future interconnected societies. Quantum Technology will play a major role in that context as it will offer inherent hardware-based security, which will also withstand future security attacks based on Quantum Computers. Major initiatives worldwide currently investigate prototypical Quantum Key Distribution (QKD) systems, which long-term will seamlessly include various different approaches including quantum repeaters, trusted nodes and satellite connections to also bridge long-haul distances. This symposium shall investigate the state of the art and future directions of quantum communications, identifying technologies and challenges for enabling a future quantum Internet. It shall shed light on how and when such approaches may be ready for implementation into optical transmission systems and networks as well as what challenges still exist.

See page 19 of this programme for a list of speakers and topics for this Symposium.

We3E • Indoor and VLC Systems - How Will Quantum Technology Revolutionize the Internet?

Organisers: Stephan Pachnicke, Kiel University, Germany
Michela Svaluto Moreolo, CTTC, Spain
Paola Farolan, Politecnico di Milano, Italy

- 13:30 Indoor Optical Wireless Communications With a Wide Field-of-View, Feng Feng, Param Sangwong-ngam, Hyunchae Chun, Grahame Faulkner, Dominic O’Brien; Univ. of Oxford, UK; Incheon National Univ., Korea (the Republic of); Tianjin Univ., China. Between a novel optical hotspot with ±30° FoV and 6 nomadic user terminals using mirror-based steering with ±50° FoV, we demonstrate point-to-multipoint bi-directional indoor optical wireless transmissions over 4 metres with flexible bandwidth resource allocation using WDM-OFDMA. Single-wavelength channel data capacity is 28 Gb/s.

- Full-duplex Bidirectional Indoor Steerable OWC System Using Orthogonal Polarization States, Nguyen Quan Pham, Ketema A. Mekonnen, Ali Melekh, Ton Koonen, Edward Tandogdolling, Eindhoven Univ. of Technology, Netherlands; KPN, Netherlands. To avoid beam-steering at users, we propose the use of same wavelength for down and upstream to realize a full-duplex bidirectional architecture using off-the-shelf XFP transceivers. Symmetric data rate of 10 Gbps is experimentally demonstrated by implementing orthogonal polarization states to mitigate the reflection crosstalk.

- 14:00 166-m Rolling Shutter Based Free Space Optical Communication (FSO) Utilizing Long Short-Term Memory Neural Network (LSTM-NN) for Decoding PAM4 Signal, Dang-Chong Tsai, Yun-Han Chang, Shang-Yen Tsai, Lu-Sheng Hsu, Chi-Wai Chow, Ching-Wei Peng, Yuan-Zeng Lin, Yin-He Jian, Ying Liu, Chien-Hung Yeh; National Yang Ming Chiao Tung Univ., Taiwan; Philips, Hong Kong; Feng Chia Univ., Taiwan. We propose and present the first demonstration of a record high 299.8-kb/s/m bit-rate distance product rolling-shutter image-sensor based free-space-optical-communication (FSO) system. Long-term-memory-neural-network (LSTM-NN) is utilized to decode the 6-level pulse-amplitude-modulation (PAM4) rolling-shutter pattern.

- 14:00 Co-Packaged Optics (CPO) and Near Packaged Optics (NPO) are driving the most dramatic industrial scale photonic integration exercise ever known, while advances in the underlying Photonic Integrated Circuit (PIC) platforms introduce exciting new materials to further reduce power consumption on optical operations and advances in thermo-plastics are opening the door to solder-reflow resistant complex, low-cost micro-optical components for higher temperature environments. Finally, the last two years have seen the introduction of quantum security products, such as quantum random number generators, of quantum networks, quantum computers and machine learning techniques. Quantum communication will become an indispensable means of securing any communication between data centres and the outside world while “Quantum as a Service” (QaaS) schemes will increasingly allow access to quantum computer facilities within the data centre. In parallel, Machine Learning techniques are expected to facilitate signal conditioning, routing and security functionalities by replacing conventional digital processing circuitry and offering a higher energy efficiency framework.

See page 19 of this programme for a list of speakers and topics for this Symposium.
Quantifying Features’ Contribution for ML-Based Quality-of-Transmission Estimation Using Explainable AI, Omar Ayoub1, Davide Andreoiu1, Sebastian Troia, Silvia Giordano1, Cristina Rottondi1, Andrea Bianco1, 1Department of Innovative Technologies, Scuola universitaria professionale della Svizzera italiana, Switzerland; 2Politecnico di Milano, Italy; 3Politecnico di Torino, Italy. We apply an explainable artificial intelligence framework to interpret quality of transmission predictions produced by a machine learning model. The framework identifies the combinations of features’ values relevant to drive the prediction process.

Optical Signal Spectrum Prediction Using Machine Learning and In-line Channel Monitors in a Multi-span ROADM System, Zehao Wang1, Emmanuel Akinrintoyo1, Daniel Kipfer1, [Redacted]1, 1Electrical and Computer Engineering, Duke Univ., USA; 2CONNECT Centre, Ireland. We measure the performance of separately characterized machine learning-based EDFA models for predicting the optical power spectrum evolution in a 5-span system with six ROADM nodes deployed in the COSMOS testbed, which achieve a mean absolute error of 0.6–0.7 dB after 10 EDFA stages under varying channel loading configurations.

Design and Fabrication of Three-Dimensional Polymer Optical Waveguide-Based Fan-in/out Device for Multicore Fibers, Yuto Yamaguchi1, 2Koe Giuku Daigaku Rikogakubu Daigaku Rikogakuen Kencyuka, Japan. In this paper, a compact 15-mode multi-plane light conversion device with a linear fiber array input, Hermite-Gaussian modes output, 8 phase masks and 65 ps pulse width is enabled to create 200–nm operation bandwidth with significantly reduced wavelength dependence compared to traditional 25 ps designs.

We3C.4 • 14:15 Invited Probabilistic Constellation Shaping and Subcarrier Multiplexing for Nonlinear Fiber Channels, Junho Cho1, Han Sun1, 1Infineon Corp, Canada. We show how the symbol rate affects the occurrence of nonlinear interference in systems with finite-length probabilistic constellation shaping. The results suggest that it is necessary to flexibly change the symbol rate according to link parameters and shaping block length to achieve optimal system performance.

We3D.4 • 14:30 Silicon Photonics IQ Modulator Targeted for 800ZR Data Center Interconnection, Jian Wang1, Wen-Jr Jiang1, You-Wei Chen1, 1Mustafa Al-Qadi1, Kangmei Li1, Konstantin Kuzmin1, Jason Acket1, David Dougherty1, Weilin Liu1, Chengkun Chen1, Hui Xu1, 1University of Queensland, Australia. We present a compact 15-mode multi-plane light conversion device with a linear fiber array input, Hermite-Gaussian modes output, 8 phase masks and 65 ps pulse width is enabled to create 200–nm operation bandwidth with significantly reduced wavelength dependence compared to traditional 25 ps designs.

We3A.2 • 14:30 Broadband 15-Mode Multiplexers Based on Multi-Plane Light Conversion With 8 Planes in Unwrapped Phase Space, Nicolas K. Fontaine1, Mikael Mazur1, Roland Ryf1, Lauren Dallachiesa1, Haochu Chen2, David T. Neilson1, Cris Bolle1, Joel Carpenter2, 1Nokia Bell Labs, USA; 2School of Information Technology and Electrical Engineering, Univ. of Queensland, Australia. We present a compact 15-mode multi-plane light conversion device with a linear fiber array input, Hermite-Gaussian modes output, 8 phase masks and 65 ps pulse width enables to create 200–nm operation bandwidth with significantly reduced wavelength dependence compared to traditional 25 ps designs.

We3A.4 • 14:35 Optical Fiber Transmission with a 75-GHz Optical Receiver, Takahashi and Yamada1. We achieved a 17.57-bit/4D symbol information rate with a net data rate of 2.29 Tbps was received after 75 km transmission using a single 211-GHz optical receiver. The use of digital pre-distortion and tailored geometric constellation shaping led to an improvement of 1.2 bit/4D symbol rate according to link parameters and shaping block length to achieve optimal system performance.

We3B.5 • 14:30 Optical Signal Spectrum Prediction Using Machine Learning and In-line Channel Monitors in a Multi-span ROADM System, Zehao Wang1, Emmanuel Akinrintoyo1, Daniel Kipfer1, [Redacted]1, 1Electrical and Computer Engineering, Duke Univ., USA; 2CONNECT Centre, Ireland. We measure the performance of separately characterized machine learning-based EDFA models for predicting the optical power spectrum evolution in a 5-span system with six ROADM nodes deployed in the COSMOS testbed, which achieve a mean absolute error of 0.6–0.7 dB after 10 EDFA stages under varying channel loading configurations.

We3A.3 • 14:45 Design and Fabrication of Three-Dimensional Polymer Optical Waveguide-Based Fan-in/out Device for Multicore Fibers, Yuto Yamaguchi1, 2Koe Giuku Daigaku Rikogakubu Daigaku Rikogakuen Kencyuka, Japan. In this paper, a compact 15-mode multi-plane light conversion device with a linear fiber array input, Hermite-Gaussian modes output, 8 phase masks and 65 ps pulse width enables to create 200–nm operation bandwidth with significantly reduced wavelength dependence compared to traditional 25 ps designs.

We3C.5 • 14:45 Highly Scored Net-bit Rate of >562-Gb/s with 32-GBaud Probabilistically Constellation-Shaped 1024QAM Signal Based on Entropy and Code-Rate Optimization, Massanori Nakamura1, 1Fujikura, Japan; 2Kukurano Hamaoka1, 1Takao Sasa1, 1Nanmi Takanash1, 1Yakuyaki Kobayashi1, 1Yoshiaki Kiseki1, 1Yutaka Miyanomoto1, 1NTT Network Innovation Laboratories, Japan. We achieved a 17.57-bit/4D symbol information rate with >562-Gb/s net rate based on precisely entropy and code-rate optimized 32-GBaud probabilistically constellation-shape (PCS-1024QAM) with an ultra-narrow-linewidth 1-Hz laser. A net rate of >542-Gb/s with an optimized PCS-1444QAM-based signal was also demonstrated for 30-km transmission.

We3D.5 • 14:45 Network 556.8 Gbps/polar Coherent Transmission Enabled by a Two-Segment All-Silicon Modulator, Zibo Zheng1, Abdolkheylhe Mohammadi2, Xiaoguang Zhang1, Leslie Rusch1, Wei Shi1, 1COPIL, Universite Laval, Canada; 2Electrical Engineering, Beijing Univ. of Posts and Telecommunications, China. We experimentally demonstrate optical coherent transmission with a segmented all-silicon modulator. Utilizing two segments, we realize 124Gbit-16QAM, 120Gbit-32QAM and 116Gbit-64QAM, enabling a maximum 556.8 Gbps/polarization net line rate.
Ultra-Dense Waveguide Arrays for Photonic Integrated Circuit, Ting Li\(^1\), Peiji Zhou\(^1\), Yucheng Lin\(^1\), Lipeng Xia\(^1\), Xiaochuan Xu\(^1\), Yi Zou\(^1\); \(^1\)ShanghaiTech Univ., China; \(^2\)Harbin Inst. of Technology Shenzhen, China. We present two half-wavelength pitched ultra-dense waveguide arrays based on artificial gauge fields (AGF). The AGF-modulated straight waveguide array exhibits an over -35 dB crosstalk suppression for the center wavelength and the bent one shows over 100 nm bandwidth for crosstalk lower than -20 dB.

Integrated Optical Phased Array for Circularly Polarized Orbital Angular Momentum Multiplexing, Yuxuan Chen\(^1\), Simon Levassure\(^1\), Leslie Rusch\(^1\), Wei Shi\(^1\); \(^1\)Department of Electrical and Computer Engineering, Center for Optics, Photonics and Lasers (COPL), Universite Laval, Canada. We design and demonstrate an on-chip tunable optical phased array that generates multiplexed circularly polarized Orbital Angular Momentum modes with record performance (24 simultaneous modes, -16.4 dB worst-case crosstalk).

Transparent Delivery of 100-GHz Radio Signal to Indoor Using Broadband Phase-Modulated RoF System, Pham Tien Dat\(^1\), Yuya Yamaguchi\(^1\), Keizo Inagaki\(^1\), Naokatsu Yamamoto\(^1\), Atsushi Kanno\(^1\); \(^1\)NICT Network System Research Inst., Japan. We demonstrate a broadband RoF system for transparent delivery of 100-GHz radio signal from outdoor to indoor using a low-loss optical phase modulator. We successfully transmitted 32-/64-QAM OFDM with a line rate of approximately 29 Gb/s over the converged system consisting of two RoF links and two radio links in the 100-GHz band.

The Role of Europe in Photonic Industry, Martin Vallo\(^1\); \(^1\)Yole Group, France. Abstract not available.

Visible Light Communication Toward 6G: Key Technologies and Future Perspectives, Nan Chi\(^1\); \(^1\)Fudan Univ., China. Abstract not available.
We3A.4 • 15:00
Highly Reliable and Low-Loss Bent Polarization Maintaining Fiber with High Polarization Extinction Ratio, Haruki Kitao¹, Tsutanu Kumagai¹, Tetsuya Nakashit¹; ¹Sumitomo Electric Industries, Japan. PMFs with ultra-small bending radius are studied for realizing space-efficient fiber coupling to CPO module. By applying Stress-free bending technique, bent PMF with high PER (>25 dB) and low loss (<0.05 dB), while no residual stress at cladding part demonstrated even at 2.2 mm-radius bending.

We3C.6 • 15:00
Concatenated SD-Hamming and KP4 Codes in DCN PAM4 4x200 Gbps/Lane, Andrei-Stefan Nedelcu¹, Stefano Calabrò¹, Youxi Lin¹, Nebojsa Stojanovic¹; ¹Huawei Technologies GmbH, Germany. We experimentally demonstrate the feasibility of serially concatenated soft-decision Hamming codes and KP4 as a backward-compatible solution for 200 Gbps/lane for IM/DD DCN applications.

We3D.6 • 15:00
Phenomenological Characterization of the Electronically Enhanced Phase Noise in Transmission Experiments, Xiaoyan Ye¹, Amirhossein Ghaizaeidi¹, Sylvain Almonacil¹, Haik Mardoyan¹, Jerome Renaudier¹; ¹Nokia Bell Labs, France. We present a novel method based on parameter extraction to characterize the variance of the electronically enhanced phase noise in ultra-long haul WDM transmission experiments. Our method does not require an a priori knowledge of the laser phase noise characteristics.

15:15–15:45 Coffee Break, Exhibition Hall 1
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<th>Time</th>
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<td>15:15–15:45</td>
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**Sessions**

- **We3E • Passive Photonic Functions—Continued**
- **We3F • Indoor and VLC Systems and Technologies—Continued**
- **We3G • Quantum Communications - How Will Quantum Technology Revolutionize the Internet?—Continued**
- **We3H • 8th International Symposium for Optical Interconnect in Data Centres III—Continued**
We4A.1 • 15:45  
**Broadband Incoherently Pumped Raman Amplification for Ultra-Long Span U-Band Transmission Systems**, Nat-supa Taengnoi, Kyle Bottrill, Yang Hong, Lajos Hanzo, Periklis Petropoulos, Optoelectronics Research Centre, University of Southampton, UK; Electronics and Computer Science, Univ. of Southampton, UK. We demonstrate broadband incoherently pumped U-band distributed Raman amplification using a transmission NZDSF as the amplifying medium, transmission of 18.4 Gb/s DP-BPSK over a single span of 285 km is demonstrated.

We4A.2 • 16:00  
**Experimental Validation of Spectral-Spatial Power Evolution Design Using Raman Amplifiers**, Mehran Soltani, Francesco Da Ros, Andrea Carena, Darko Zibar, Technical University of Denmark, Denmark; Politecnico di Torino Dipartimento di Elettronica e Telecomunicazioni, Italy. We experimentally validate a machine learning-enabled Raman amplification framework, capable of jointly shaping the signal power evolution in two domains: frequency and fiber distance. The proposed experiment addresses the amplification in the whole C-band, by optimizing four first-order counter-propagating Raman pumps.

We4A.3 • 16:15  
**Stimulated Brillouin Scattering in Chiral Photonic Crystal Fibre**, Xinglin Zeng, Birgit Stiller, Max-Planck-Institut, Germany. We experimentally demonstrate topology-selective stimulated Brillouin scattering in a twisted photonic crystal fiber. This allows us to implement a vortex Brillouin laser and amplification of specific optical modes carrying orbital angular momentum and circular polarization. Moreover, we show nonreciprocal manipulation of vortex modes.

We4B.1 • 15:45  
**Distributed Fiber Sensing Applications**, Glenn Wellbrock, Verizon Inc, USA. Abstract not available.

We4B.2 • 16:15  
**Research and Experiment on AI-Based Co-Cable and Co-Trench Optical Fibre Detection**, Yunbo Li, Chuan Li, Zhe Liu, Tao Zhang, Sheng Liu, Dawei Ge, Yuren You, Jibiao Zhang, Dong Wang, Yang Zhao, Dechao Zhang, Han Li, China Mobile Research Inst., China; Huawei Technologies Co Ltd, China. A novel AI-based co-cable and co-trench optical fibre detection method is proposed based on twin neural network and extraction of multimodal features, e.g. fibre static, dynamic, and site features. The detection accuracies of the solution in the test and field trial network are over 90%.

We4B.3 • 16:15  
**Improved Pre-Compensation to Combat Power Fading in IM/DD Systems**, Tom Wettlin, Stefano Calabro, Taffa Rahman, Md Sabbir Bin Hossain, Jinlong Wei, Nebboja Stojanovic, Stephan Pachnicke, Christain-Albrechts-University of Kiel, Germany; Huawei Technologies Deutschland GmbH, Germany. We propose a pre-compensation approach allowing an improved compensation of spectral nulls caused by CD-induced power fading in IM/DD systems. We show a gain by the proposed scheme in 35 km PAM4 C-band transmission experiments at rates in the order of 50 Gb/d.

We4C.1 • 15:45  

We4C.2 • 16:15  
**Improved Pre-Compensation to Combat Power Fading in IM/DD Systems**, Tom Wettlin, Stefano Calabro, Taffa Rahman, Md Sabbir Bin Hossain, Jinlong Wei, Nebboja Stojanovic, Stephan Pachnicke, Christain-Albrechts-University of Kiel, Germany; Huawei Technologies Deutschland GmbH, Germany. We propose a pre-compensation approach allowing an improved compensation of spectral nulls caused by CD-induced power fading in IM/DD systems. We show a gain by the proposed scheme in 35 km PAM4 C-band transmission experiments at rates in the order of 50 Gb/d.

We4D.1 • 15:45  
**8.375-THz Optical Amplification for Wideband WDM Transmission by Optical Parametric Amplifier Using Cascaded PPLN Modules With Complementary Gain Profiles**, Shimpie Shimizu, Takayuki Kobayashi, Takushi Kazama, Takeshi Umeki, Masanori Nakamura, Koji Enbutsu, Takeshiro Kashiwazaki, Fukutaro Hamaoka, Munehiko Nagatan, Hiroshi Yamazaki, Kei Watanabe, Yutaka Miyamoto, NTT Corporation, Japan. We propose a configuration of an optical parametric amplifier using cascaded PPLN modules with different phase-matching characteristics for pump-power-efficient bandwidth extension. We demonstrate 8.375-Thz (1548.81–1618.86 nm) optical amplifier with >15-dB gain using the proposed configuration under a 125-GHz-spaced 67-channel 800-Gbps A WDM transmission condition.

We4D.2 • 16:00  
**Capacity of Phase-Sensitive Preamplified Optical Links at Low Signal-to-Noise Ratio**, Kevendhan Vijayan, Ali Mirani, Jochen B. Schroeder, Magnus Karlsson, Peter Andrekson, Chalmers tekniska hogskola, Sweden. We experimentally show that phase-sensitive preamplified links have higher spectral efficiency than using conventional amplifiers at low signal-to-noise ratios. At 10 Gbaud, 4QAM modulation provides the best spectral efficiency at received powers below -59.7 dBm and 16-QAM from -59.7 dBm to -55.2 dBm.

We4D.3 • 16:15  
**Demonstration of up to 480-km BDFA-Based WDM Transmission by Optical Parametric Amplifier Using Cascaded PPLN Modules With Complementary Gain Profiles**, Shimpie Shimizu, Takayuki Kobayashi, Takushi Kazama, Takeshi Umeki, Masanori Nakamura, Koji Enbutsu, Takeshiro Kashiwazaki, Fukutaro Hamaoka, Munehiko Nagatan, Hiroshi Yamazaki, Kei Watanabe, Yutaka Miyamoto, NTT Corporation, Japan. We propose a configuration of an optical parametric amplifier using cascaded PPLN modules with different phase-matching characteristics for pump-power-efficient bandwidth extension. We demonstrate 8.375-Thz (1548.81–1618.86 nm) optical amplifier with >15-dB gain using the proposed configuration under a 125-GHz-spaced 67-channel 800-Gbps A WDM transmission condition.

**Invited Session**

**We4A.4**

**Highly Scored**

**15:45**

**Demonstration of up to 480-km BDFA-Based WDM Direct-Detection Transmission in the O-Band**, Yang Hong, Nat-supa Taengnoi, Kyle Bottrill, Yu Wang, Jayanta K. Rahman, Abdur Rahman, Ali Mirani, Kyle Bottrill, Periklis Petropoulos, David Richardson, Univ of Southampton, UK. We report on experiments of 3×50-Gb/s O-band WDM direct-detection transmission using a BDFA-based optical recirculating loop. Record-long transmission distances up to 480 km are achieved at the 50-PEC limit in experiments with two different channel spacings.

**16:30**

**Invited Session**

**We4C.3**

**Highly Scored**

**16:15**

**Improved Pre-Compensation to Combat Power Fading in IM/DD Systems**, Tom Wettlin, Stefano Calabro, Taffa Rahman, Md Sabbir Bin Hossain, Jinlong Wei, Nebboja Stojanovic, Stephan Pachnicke, Christain-Albrechts-University of Kiel, Germany; Huawei Technologies Deutschland GmbH, Germany. We propose a pre-compensation approach allowing an improved compensation of spectral nulls caused by CD-induced power fading in IM/DD systems. We show a gain by the proposed scheme in 35 km PAM4 C-band transmission experiments at rates in the order of 50 Gb/d.

**16:30**

**Invited Session**

**We4D.5**

**Highly Scored**

**16:15**

**Improved Pre-Compensation to Combat Power Fading in IM/DD Systems**, Tom Wettlin, Stefano Calabro, Taffa Rahman, Md Sabbir Bin Hossain, Jinlong Wei, Nebboja Stojanovic, Stephan Pachnicke, Christain-Albrechts-University of Kiel, Germany; Huawei Technologies Deutschland GmbH, Germany. We propose a pre-compensation approach allowing an improved compensation of spectral nulls caused by CD-induced power fading in IM/DD systems. We show a gain by the proposed scheme in 35 km PAM4 C-band transmission experiments at rates in the order of 50 Gb/d.
We4E.1 • 15:45
High Baudrate Silicon Photonics for the Next-Generation Optical Communication, Xi Xiao1,2, Lei Wang1,5, Ming Luo1, Xiao Hu1,3, Daigao Chen1,2, Hongguang Zhang1,2, Yuguang Zhang1, Peng Feng1,3, Jin Tao1, Yanfeng Fu1, Dong Wang1, Zhixue He1,2, Shaohua Yu1,2, 1National Information Optoelectronics Innovation Center, China; 2China Information and Communication Technologies Group Corporation (CICT), China; 3Peng Cheng Laboratory, China. A silicon photonic integrated coherent transmitt & receive optical sub-assembly with the baud rate beyond 100Gbaud is developed for the next-generation optical communications. Based on this device, 1.06Ps/s transmission over a 19-core fiber, 16Tb/s transmission over 10000km G.654E fiber, and 336Tb/s real-time transmission over 332km are demonstrated.

We4E.2 • 16:15
Silicon MOS-Capacitor Modulators: Scaling the Modulation Bandwidth, Phase Efficiency and Compactness, Weewei Zhang1,2, Arian Hashemi1,2, Martin Ebert1, Ke Li1, Mingwo Wang2, Biqeng Chen1, Graham Reed1, Azita Emaimi1,2, David Thomson1; 1Univ. of Southampton, UK; 2Califomia Inst. of Technology, USA. We report silicon lateral MOS-capacitor modulators integrated within different thickness SOI wafers. The MZI modulators with lumped 2-segment electrodes are flip-chip bonded with CMOS drivers showing capability of 50 Gbaud PAM-4 transmission with 4 dB extinction ratio, 1.74 dB TDCER and 2.4 pJ/bit power consumption.

We4F.1 • 15:45
Tutorial
Satellite-Based Quantum Key Distribution, Christoph Marquardt1,1; Max-Planck-Institut für die Physik des Lichts, Germany. Currently deployed cryptographic methods are at risk by future attacks e.g. by quantum computer algorithms. Satellite-based quantum key distribution offers worldwide long-term security for critical infrastructure and secure communication. I will review concepts and discuss current activities.

Today’s artificial intelligence (AI) performance has been significantly improved thanks to the CMOS technology and the high computational power brought by graphics processing units (GPUs) and application specific integrated circuits (ASICs). However, to keep up with this trend, a critical problem should be solved, the inherent high energy consumption induced by the continuous exchange of data between the memory and computing units, which are physically separated. This issue is known as the “von Neumann bottleneck.” Several innovations in the field of information technology have shown promise in overcoming this fundamental limit. For example, recent developments of memristors, a class of two-terminal nano-devices with a variable resistance, enables the collocation of the computing and storing functionalities, thus circumventing the limitations of current von Neumann designs. On the other hand, progress in standard photonic circuits allows for high-bandwidth optical data communication. Ideally, a photonic-electronic platform is desired that can simultaneously take advantage of the high density and non-volatility of electronic memristors and of the high-speed communication capabilities provided by photonics/plasmonics components. In this symposium, we will discuss the challenges and opportunities of this platform.

The symposium is divided into three sessions. Session 1 will cover the theoretical aspects related to the understanding of the interplay between photonic, electronic, phononic and ionic interactions within memristors. Session 2 will focus on the materials needed for novel memristive material stacks. Session 3 will be related to the device engineering and novel opto-electronic applications.

See page 19 of this programme for a list of speakers and topics for this Symposium.

We4F.2 • 16:15
Satellite Based Optical Freespace Communication II
Presider: Reto Muff; Thales Alenia Space France, France

We4G • Photonic-Electronic Memristors for Neuromorphic Applications
Organiser: Alexandros Emboras, ETH Zurich, Switzerland

We4H • 8th International Symposium for Optical Interconnect in Data Centres IV
Organisers: Tolga Tekin, Fraunhofer IZM, Germany; Richard Pitwon, Resolute Photonics, Ireland; Dimitrios Apostolopoulos, National Technical University of Athens, Greece; Paraskevas Bakopoulos, NVIDIA, Greece

Data centres have continued to evolve dramatically over the past two years with hyperscale now the dominant form of data centre in the world, accelerating the convergence of 5G/6G and even quantum interconnect with traditional datacom into future data centres. This annual symposium continues to evolve accordingly to address these new disruptive technologies.

We address evolution of optical interconnect at the front panel with higher density SN/MDC type connectors, which increase optical channel density at the font panel dramatically over traditional MPO. Co-Packaged Optics (CPO) and Near Packaged Optics (NPO) are driving the most dramatic industrial scale photonic integration exercise ever known, while advances in the underlying Photonic Integrated Circuit (PIC) platforms introduce exciting new materials to further reduce power consumption on optical operations and advances in thermo-plastics are opening the door to solder-reflow resistant complex, low-cost micro-optical components for higher temperature environments.

Finally, the last two years have seen the introduction of quantum security products, such as quantum random number generators, of quantum networks, quantum computers and machine learning techniques. Quantum communication will become an indispensable means of securing any communication between data centres and the outside world while “Quantum as a Service” (QaaS) schemes will increasingly allow access to quantum computer facilities within the data centre. In parallel, Machine Learning techniques are expected to facilitate signal conditioning, routing and security functionalities by replacing conventional digital processing circuitry and offering a higher energy efficiency framework.

See page 19 of this programme for a list of speakers and topics for this Symposium.
We experimentally demonstrate an orthogonal-Pump FWM Systems, Hao Liu, Kyle Bottrill, Ali Masoudi, Valeria Vitali, Periklis Petropoulos, Univ. of Southampton, UK. We experimentally demonstrate an optical time-domain reflectometry system with 50 cm spatial resolution, capable of measuring the onset of polarization dependency of orthogonal-pump four-wave mixing systems in the saturation regime. Close agreement with theoretical predictions is observed.

We perform a 201.6 km-long unrepeated optical time-domain reflectometry system with 50 cm spatial resolution, capable of measuring the onset of polarization dependency of orthogonal-pump four-wave mixing systems in the saturation regime. Close agreement with theoretical predictions is observed.

Improved Polarization Tracking in the Presence of PDL, Mohammad Farsi, Christian Häger, Magnus Karlsson, Erik Agrell, Department of Electrical Engineering, Chalmers tekniska högskola, Sweden; Department of Microtechnology and Nanoscience, Chalmers tekniska högskola, Sweden. We propose a novel tracking algorithm for optical channels suffering from fast state of polarization (SOP) rotations and polarization-dependent loss (PDL). Unlike gradient descent-based algorithms that require step size adjustment when the channel conditions change, our algorithm performs similarly or better without parameter tuning.

Few-bit Quantization of Neural Networks for Nonlinearity Mitigation in a Fiber Transmission Experiment, Jamal Darweesh, Nelson Costa, Antonio Napoli, Bernhard Spinnler, Yves Jaouen, Mansoor Yousefi, Telecom-paris, France; Infinera, Portugal; Infinera G, Germany. A neural network is quantized for mitigation of nonlinearity and components’ distortions in a 16-QAM 9x50km dual-polarization fiber transmission experiment. Post-training additive power-of-two quantization at 6 bits incurs a negligible Q-factor penalty. At 5 bits, the model size is reduced by 85%, with 0.8 dB penalty.

Real-Time 59.2 Tb/s Unrepeated Transmission Over 201.6 km Using Ultra-Wideband SOA as High Power Booster, Xiaohui Zhao, Dylan Le Gac, Salma Escobar Landero, Josef Demirizoglou, Abel Lorenzes-Riesgo, Loig Godard, Nayla El Dahdah, Ge Gao, Romain Brenot, Yann Frigacq, Gabriel Charlet, Huawei Technologies France SAS, France. We perform a 201.6 km-long unrepeated transmission using an UWB seamless SOA with a maximum output power of 24.4 dBm jointly with backward distributed Raman pumping achieving 59.2 Tb/s total throughput using real-time transponders.
We4E.3 • 16:30
**Ultra-High-Q Racetrack on Thick SOI Platform Through Hydrogen Annealing**, Yisel Marin\(^1\), Anjit Bera\(^1\), Matteo Cherchi\(^1\), Timo T. Aalto\(^1\); \(^1\)Teknologian tutkimuskeskus VTT Oy, Finland. We experimentally demonstrate a racetrack resonator consisting of rib waveguides and strip-waveguide-based Euler bends on thick SOI platform, with an intrinsic quality factor of 14 million, corresponding to a propagation loss of 2.7 dB/m. This result was achieved through sidewall roughness smoothing using hydrogen annealing.

We4F.2 • 16:45
**Invited How Far Could we Stretch the Capacity of Optical Satellite Communications?**, Sebastien Bigo\(^1\), Daniel Romero\(^2\), Sylvain Almonacil\(^1\), Rajiv Boddeda\(^1\); \(^1\)Nokia Bell Labs, France; \(^2\)Office National d’Etudes et de Recherches Aerospatiales, France. While digital coherent free-space optics is foreseen as the enabling technology for next generation high throughput satellite, molecular absorption and turbulence through the atmosphere restrain the possibility to fully use the optical amplifier bandwidth. We discuss the capacity limits of such systems.

We4E.4 • 16:45
**Crossbar Wiring for III-v/Si MOS Optical Phase Shifters With Diode Selectors**, Hanzhi Tang\(^1\), Rui Tang\(^1\), Junichi Fujikata\(^1\), Masataka Noguchi\(^2\), Shigeki Takahashi\(^1\), Kasdit Toprasertpong\(^1\), Shinichi Takagi\(^2\), Mitsuru Takenaka\(^1\); \(^1\)The Univ. of Tokyo, Japan; \(^2\)Tokushima Univ., Japan; \(^3\)Kokuritsu Kenkyu Kaihatsu Hojin Sangyo Gijutsu Sogo Kenkyujo, Japan; \(^4\)Photonics Electronics Technology Research Association, Japan. We proposed a crossbar wiring scheme for voltage-driven III-V/Si MOS optical phase shifters with diode selectors. We experimentally demonstrated the pulse-amplitude control and verified the selection functionality. The power consumption of crossbar wiring scheme was 700 times lower than that for thermo-optic phase shifters.
Component Fault Location in Optical Networks Based on Attention Mechanism with Monitoring Data, Chuidian Zeng, Jiawei Zhang, Ruikun Wang, Bojun Zhang, Yuefeng Ji, Beijing Univ. of Posts and Telecommunications, China. Targeting component fault location in optical networks, we propose a strategy based on attention mechanism, which includes three attention models. Simulation results indicate that the proposed strategy can achieve improvement of location accuracy by focusing on more critical monitoring data.

Decision Trees for Event Signature Classification on Fiber Optic Cables in Quaternion Coordinates, Essen Dossev, Peter Djukic, Christine Tremblay, Ciena, Canada. Proximal events posing risks to network service were classified using Decision Trees on State of Polarization Multivariate Time Series data. Aggregate features of interests were individually evaluated to determine their significance, demonstrating that a combination of two aggregate sufficed to produced 98.8% event classification accuracy.

Simultaneous Sensing and Communication in Optical Fibers, Yue-Kai Huang, Ezra Ip, Junqiang Hu, Ming-Fang Huang, Fatih Yaman, Ting Wang, Glenn Wellbrock, Tiejun Xia, Koji Asahi, Yoshiaki Aono, NEC Laboratories America Inc., USA; Verizon, USA; Photonic System Development Department, NEC Corporation, Japan. We explore two fiber sensing methods which enables coexistence with data transmission on DWDM fiber networks. Vibration detection and localization can be achieved by extracting optical phase from modified coherent transponders. Frequency-diverse chirped-pulse DAS with all-Raman amplification can improve SNR and achieves multi-span monitoring.

Multiple Beat-Noise Suppression in Polarization-Multiplexed Pump Light for Forward-Pumped Raman Amplifier, Hiroto Kawakami, Takayuki Kobayashi, Yoshiaki Kisa-ka, NTT Corporation, Japan. We show that orthogonally polarized pump light emitted from two different laser sources in a forward-pumped Raman amplifier system induces beat noise on amplified signal light. Utilizing our proposed noise suppression technique, we improved the SNR of a 36-QAM signal after a 1,920-km transmission.

Rump Session: Analysis and Real Opportunities from the Hyped Big Trends in Photonics
Organiser & Moderator: Jose Pozo, CTO, Optica, USA
See page 116 of this programme for more information about this event.
We4E.5 • 17:00
Integrated Microwave Photonic Phase Shifter With Ultrahigh Dynamic Range, Kaixuan Ye1, Gaojan Liu1, Olkky Daulay1, Marcel Hoekman1, Edwin Klein1, Chris Roeloffzen1, David Marpaung1; 1Universiteit Twente, Netherlands; 2LionX International BV, Netherlands. We experimentally demonstrate, for the first time to the best of our knowledge, an integrated microwave photonic phase shifter with ultra-high dynamic range. We achieved 2π tunable phase shift with amplitude variation of < 1 dB and spurious-free dynamic range of 121.6 dB° Hz⁴/₅.

We4E.6 • 17:15  🟢 Highly Scored
Slice-Less Optical Arbitrary Waveform Measurement (OAWM) on a Silicon Photonic Chip, Daniel Drayss1,3, Dengyang Fang1, Christoph Füllner1, Artem Kuzmin2,1, Wolfgang Freude1, Sebastian Randel1, Christian Koos1,2; 1Inst. of Photonics and Quantum Electronics (IPQ), Karlsruhe Institute for Technology, Germany; 2Laboratory for Applications of Synchrotron Radiation, Karlsruhe Institute for Technology, Germany; 3Inst. of Microstructure Technology (IMT), Karlsruhe Institute for Technology, Germany. We demonstrate the first slice-less optical-arbitrary-waveform-measurement (OAWM) front-end integrated on a silicon photonic chip and demonstrate its viability by reception of high-speed data signals (100 GBd 64 QAM). Our system covers a bandwidth of more than 160 GHz and exploits an accurate calibration for high-fidelity signal reconstruction.
### 08:30–10:15
#### Th1B • Free Space Optical Communication for Terrestrial & Space Applications I
**Organiser:** Reto Muff, Thales Alenia Space, Switzerland

Free Space Optical Communication (FSO) has become an impressive momentum over the past years. For a long time, FSO applications for space borne systems have been deployed as niche and at significant cost. Global efforts to make reliable use of novel technologies and building blocks developed for non-space applications («COTS») now pay off and the deployment of FSO for a large range of space-based use cases has become reality. In parallel to the space domain, FSO has become an alternate to other classical communication means and will further grow in importance helping to overcome bottlenecks in RF arising from the ever-growing capacity needs of mankind.

This Symposium is intended to give a updated overview on the status on development and deployment of FSO in the various scenario, such as Space based systems, mid and short range FSO in atmosphere but will also address enabling technologies to support specific needs for FSO systems.

See page 20 of this programme for a list of speakers and topics for this Symposium.

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#### Th1A.1 • 08:45
**Simple Multi-Core Fiber Fabrication Method**, Pierre Sillard¹, Jean-Baptiste Trinel¹, Alain Giuliani¹, Dimitri Vanhuyse¹, Maryna Kudinova¹, Frank Achten¹; Prysmian Group, France. We report a simple multi-core fiber fabrication method that uses standard manufacturing processes except for a stacking step, made with a limited number of adjusting rods. A 4-core fiber with 125µm-cladding and 200µm-coating diameters, and good optical and mechanical properties is fabricated using this method.
Th1A.2 • 09:00 Invited
Thermal Sensitivity of Optical Fibres and How to Reduce it, Radan Slavik¹, Eric Numkam Fokoua¹, Zitong Feng¹, Meng Ding¹, Francesco Paletti¹, David Richardson¹, ¹Univ. of Southampton, UK. Light propagating through an optical fibre changes its phase and group delay due to ambient temperature variations. This is detrimental in timing-sensitive applications, including telecom. We review strategies to reduce this effect, focusing mostly on hollow core optical fibres.

Th1C.3 • 09:15
Robust Pilot-Aided Timing Recovery Algorithm for OFDM-Based Digital Multi-Band Systems, Wanzhen Guo¹, Zhaquan Fan¹, Zhiheng Zhang¹, Jiating Luo¹, Bofang Zheng¹, Jian Zhao¹, ¹South China Univ. of Technology, China; ²Huawei Technologies Co Ltd, China. We propose the first timing recovery algorithm for OFDM-based digital multi-band (DMB) systems where Gardner, Godard and square-Gardner algorithms fail. 320-Gbit/s experiments and simulations show that QAM-DMB using the proposed algorithm outperforms QAM-DMB using conventional algorithms and is also robust to spectral rolloff and DGD.

Th1C.3 • 09:30
Transfer Function Equalization Enhanced Phase Noise in Generalized Carrier Assisted Differential Detection Receivers, Honglin Ji², Jingchi Li³, Xingfeng Li³, Zemin Wang³, Ranjith Rajasekharan Unnithan¹, Yikai Su¹, Wesheng Hu², ¹The Univ. of Melbourne, Australia; ²Peng Cheng Laboratory, China; ³Shanghai Jiao Tong Univ., China. We analyze the equalization enhanced phase noise (EENP) in carrier-assisted differential detection (CADD) and its dependence on the receiver transfer function. For CADD, by using optical filters instead of a pure optical delay, the EENP effect could be greatly alleviated when using the transmitter lasers with a large linewidth.

Th1A.3 • 09:30 Invited
3D Printed Chalcogenide Fibers, Johann Troles¹, ¹Université de Rennes 1, France. By using an original additive manufacturing method, chalcogenide glass preforms with complex designs can be fabricated in a single step. This original 3D printing method, opens the way to many applications involving chalcogenide glass manufacturing but also many other chalcogenide glass optical components.
We report the first continuous-wave transmission were observed. in back-to-back and clear PAM4 eye diagrams after 2km and 1331nm wavelengths. 4.5dB extinction a packaged electroabsorption modulated laser at 1271nm China.

420 Gbps PAM8 Operation Using 93 GHz Bandwidth Lumped-Electrode Type EA-DFB Laser at 50°C Beyond 400 Gbps/Lane, Hideaki Asakura1, Kazuki Nishimura1, Sinya Yamauchi1, Yoshhiro Nakai1, Takanori Suzuki1, Yoriiyoshi Yamaguchi1, Kentaro Tan1, Ryosuke Nakajima1, Kazuhiro Naone1, Lumentum Japan, Inc., Japan. 420 Gbps (140 Gbaud) PAM8 operation using a lumped-electrode EA-DFB laser was demonstrated with clear eye-openings over 500 m and 2 km transmissions. The output power and the extinction ratio were 9.1 dBm and 3.7 dB, respectively, with 0.9 Vpp swing at 50°C.

A Low Chirp Electroabsorption Modulated Laser Suitable for 200Gb/s PAM4 CWDM Transmission Over 2km, Xin Chen1, Richard Cronin1, Haibo Wang1, Malcolm Pat1, Ping Liao1, Kexin Bang2, Jiaxin Zhao1, Linfeng He1, Junfeng Liu1, Eva Repiso1, David Rogers1, Chaoyi Wang1, Graham Berry1, Xuefeng Liu1, Bo Zhou1, 1(Hisilicon Optoelectronics Co., ltd., Ipswich Research Centre, UK; 2Hisilicon Optoelectronics Co., ltd., Wuhan Research Inst., China. 2000Gb/s PAM4 operation was demonstrated using a packaged electroabsorption modulated laser at 1271nm and 1331nm wavelengths. 4.5dB extinction ratio at 1.0Vpp in back-to-back and clear PAM4 eye diagrams after 2km transmission were observed.

Low Power Consumption 2D Beam Scanner Integrated With Wavelength Tunable Laser Diode, Yamato Misugi1, Hideaki Okayama1, Tomohiro Kita1, Waseda Daisaku Riko Gakujutsuin, Japan; 2Oki Electric Industry Co. Ltd., Japan. In this paper, we fabricated a 6 × 1.5 mm² 1-chip beam steering device by integrating a laser diode with an OPA that doesn’t have any phase shifters. Power consumption for beam steering is 65 mW. Beam steering range is 42.2 ° × 9.54 °.
Th1C.5 • 09:45 **Highly Scored**
Spiking Neural Network Equalization on Neuromorphic Hardware for IM/DD Optical Communication, Elias Arnold¹, Georg Bocherer¹, Eric Mueller¹, Philipp Spilger¹, Johannes Schiemann³, Stefano Calabrò², Maxim Kuschnerov²; ¹Ruprecht Karls Universitat Heidelberg Kirchhoff-Institut fur Physik, Germany; ²Huawei Technologies Deutschland GmbH, Germany. A spiking neural network (SNN) nonlinear equalizer model is implemented on the mixed-signal neuromorphic hardware system BrainScaleS-2 and evaluated for an IM/DD link. The BER 1e-3 is achieved with a hardware penalty smaller than 1 dB, outperforming numeric linear equalization.

Th1C.6 • 10:00
High Dynamic Range 100 Gbit/s PAM4 PON With SOA Preamplifier Using Gated Recurrent Neural Network Equalizer, Stephen L. Murphy¹, Faniba Jamal¹, Paul D. Townsend¹, Cletus Antony¹; ¹Tyndall National Inst., Ireland. We investigate parallel multi-symbol equalization scheme for 100Gbps/sA PAM4 using Gated Recurrent Neural Networks and exploit SOA preamplifier gain suppression to achieve 27 dB system dynamic range below hard-decision FEC BER limit of 3.8 x 10⁻³ using a receiver with two gain settings. © 2022 The Author(s)
high-speed Transmitter Devices—Continued

Th1E.5 • 09:45  
200 Gb/s Uncooled EML With Single MQW Layer Stack Design, Michael A. Theurer1, Christoph Kottke1, Ronald Freund1, 2, Felix Ganzer1, Patrick Runge1, Martin Moehrle1, Ute Troppenz1, Aniane Sigmund1, Martin Schell1; 1Fraunhofer Heinrich Hertz Inst., Germany; 2Technische Universität Berlin, Germany. We demonstrate an EML for 200 Gb/s PAM4 modulation at uncooled conditions. The device has an identical MQW layer stack for the DFB, EAM and SOA section, which allows a simple fabrication process. The EML is designed for balanced performance from 20°C to 85°C.

Th1E.6 • 10:00  
Record High Power 13dBm Electro-Absorption Modulated Laser for 50G-PON, Natalia Dubrovina1, Elena Duran2, Hélène Debregeas1, Ricardo Rosales3, François Lelarge1, Romain Brenot2; 1Almae Technologies, France; 2Huawei Technologies Munich, Germany; 3Huawei Technologies Paris, France. We present a 50Gb/s electro-absorption modulated laser emitting at 1342-1358nm and optimised to provide high output power and efficient modulator extinction. With a record modulated output power of >13dBm (ex-facet) and a 6dB dynamic extinction ratio it can serve for 50G-PON as unamplified transmitter.

Th1F • Novel PICs and Applications—Continued

Th1F.3 • 09:45  
A Fast-Locking Electro-Optic PLL (EOPLL) With Lock-in Calibration (LIC) and Harmonic Suppression for LiDAR, Jinhai Xiao1, Weigang Ge1, Siyuan Li1, Liang Ning1, Maliang Liu1; 1Xidian Univ. School of Microelectronics, China. A novel EOPLL of FMCW LiDAR is proposed to eliminate the influence of temperature, process, and voltage (PVT) on the laser. Harmonic reduction mixer (HRM) with better rejection and LIC for improved EOPLL settling time are proposed.

Th1F.4 • 10:00  
Highly Scored  
All-Optical Dual-Polarization MIMO Processor Based on Integrated Optical Unitary Converter, Ryota Tanomura1, Rui Tang2, Go Soma1, Shota Ishimura1, Takuo Tanemura1, Yoshiaki Nakano1; 1The Univ. of Tokyo, Japan; 2KDDI Research, Japan. A 6-port optical unitary converter circuit with polarization-splitter-rotators is realized on a compact silicon photonic chip. All-optical MIMO demultiplexing of 300-Gbps 3-modes DP-QPSK signal is demonstrated with an energy consumption of around 1.5 pJ/bit.

Th1G • Quantum Communication—Continued

Th1G.6 • 09:45  
Invited  
Microwave-Optical Transduction With Integrated Gallium Phosphide Devices, Simon Hönl1, Youri Popoff2, Daniele Caimi1, Alberto Beccari1, Tobias Kippenberg2; 1IBM Research GmbH, Switzerland; 2Ecole Polytechnique Federale de Lausanne Faculte des Sciences et Techniques de l’Ingenieur, Switzerland. Optomechanical resonators provide a route to interconversion of microwave and optical photons for quantum interconnects. We present a platform comprising a GaP photonic crystal cavity integrated on prefabricated niobium circuits, with mechanical modes at ~3.2 GHz and optomechanical coupling rates up to g0/2π = 300 kHz.

10:15–10:45 Coffee Break, Foyer 2nd Floor
We propose a receiver-side digital nonlinear distortion compensation (NLC) that solves a time-evolving equation for SOA-induced nonlinear distortion with SOA networks for high baud rate (> 128 Gbaud) optical coherent transmission. We investigate the performance of recurrent NN architectures for this task.

Th2D.1 • 10:45 Tutorial
The Role of Standardization, Interoperability, and Open Ecosystems in Hyperscale Data Centers, Mark M. Filer, Google Inc., USA. This tutorial highlights recent efforts toward enabling hyperscale data center networks which employ standardized, interoperable, and/or open hardware and software.

Th2D.2 • 11:15
Digital Compensation for SOA-Induced Nonlinear Distortion in Ultra-High Symbol Rate Signals, Fukutarou Hamazaki, Masanori Nakamura, Takeo Sasai, Takayuki Kobayashi, Munehiko Nagasani, Hitoshi Wakita, Hiroshi Yamazaki, Yoshihiro Ogiso, Yutaka Miyamoto, NTT Network Innovation Laboratories, Japan; ‘NTT Device Technology Laboratories, Japan; ‘NTT Device Innovation Center, Japan. We propose a receiver-side digital nonlinear compensation (NLC) that solves a time-evolving equation for SOA-induced nonlinear distortion with SOA device parameters estimated by our ultra-broadband flexible-rate transmitter configuration. Experiments demonstrate that our SOA-NLC suppresses the SNR penalty by SOA for 168-Gbaud signals to <0.29 dB. 

Th2C.1 • 10:45
Performance Analysis of Recurrent Neural Network-Based Digital Pre-Distortion for Optical Coherent Transmission, Vinod Bajaj,1,2,1 Vahid Aref,1 Sander Wahls,2,1 Nokia Solutions and Networks GmbH und Co KG Stuttgart, Germany; 2Technische Universität Delft, Netherlands. A recently developed neural network (NN)-based digital pre-distortion method for a high baud rate (128 Gbaud) optical coherent transmitter utilized a feed-forward architecture. In this paper, we investigate the performance of recurrent NN architectures for this task.

Th2C.2 • 11:15
Optical Amplifier Nonlinear Distortion Suppression with Recurrent Neural Networks, Sander Wahls,2,1 Vahid Aref,1 Sander Wahls,2,1 Nokia Solutions and Networks GmbH und Co KG Stuttgart, Germany; 2Technische Universität Delft, Netherlands. We report the performance of CW and pulsed single-clad PM Tm-doped fibre amplifiers optimized for 1760-1960 nm wavelength band. We have achieved 3 W of CW output power and 20 W of peak power (1.56 μJ pulse energy, τ = 100 ns, DC = 10%) at 1760 nm. Rectangular output pulses were achieved by using pulse preshaping technique.

Th2B.1 • 10:45
Extending L-Band Gain to 1625 nm Using Er3+:Yb3+ Co-Doped Silica Fibre Pumped by 1480 nm Laser Diodes, Ziwei Zhai,1,2,1 Jayanta K. Sahu,1,2 Univ. of Southampton Zepler Inst. for Photonics and Nanoelectronics, UK. We report a high-concentration Er3+:Yb3+ co-doped phospho-alumino-silicate fibre providing 18.4±3.9dB multi-channel gain with 5.8dB average NF from 1570-1616nm. At 1616nm, the gain was 19.3dB at 20°C and 25.3dB at -60°C, with a -0.065%/°C temperature-dependent-gain coefficient. Also, a 10dB single-channel small-signal gain was obtained at 1625nm.

Th2B.2 • 11:30
Free Space Optical Communication for Terrestrial & Space Applications II, Reto Muff,1 Thales Alenia Space, Switzerland. We report a first-time ultra-wideband transmission through 70-km long fiber enabled by hybrid amplifier based on bismuth-doped fiber and discrete Raman amplification. The experiment features 193-nm 30 Gbaud PM-16-QAM signal amplified with 15 dB gain and 6 dB NF. Free Space Optical Communication (FSO) has become an impressive momentum over the past years. For a long time, FSO applications for space borne systems have been deployed as niche and at significant cost. Global efforts to make reliable use of novel technologies and building blocks developed for non-space applications (e.g., COTS) now pay off and the deployment of FSO for a large range of space-based use cases has become reality.

In parallel to the space domain, FSO has become an alternate to other classical communication means and will further grow in importance helping to overcome bottlenecks in RF arising from the ever-growing capacity needs of mankind. This Symposium is intended to give an updated overview of the status on development and deployment of FSO in the various scenario, such as Space based systems, mid and short range FSO in atmosphere but will also address enabling technologies to support specific needs for FSO systems.

See page 20 of this programme for a list of speakers and topics for this Symposium.

Th2A.3 • 11:15
1760 nm Multi-Watt Broadband PM CW and Pulsed Tm-Doped Fibre Amplifier, Viktor T. Walaski, Robert E. Tench, Gustavo Rivas, Jean-Marc Delavaux, Ian Farley; CYBEL LLC, USA; 2Eblana Photonics, Ireland. We report the performance of CW and pulsed single-clad PM Tm-doped fibre amplifiers optimized for 1760-1960 nm wavelength band. We have achieved 3 W of CW output power and 20 W of peak power (1.56 μJ pulse energy, τ = 100 ns, DC = 10%) at 1760 nm. Rectangular output pulses were achieved by using pulse preshaping technique.
We experimentally present a low-complexity \(2\)-1 st-order optical parametric amplifier in a photonic circuit, Johann Riemensberger,\(^1\) Nikolai Kusnetsov\(^2\),\(^3\) Junqiu Liu,\(^1\) Jijun He,\(^1\) Rui N. Wang,\(^1\) Tobias Kippenberg,\(^1\) \`Ecole Polytechnique Federale de Lausanne, Switzerland;\(^2\) Russian Quantum Center, Russian Federation. We demonstrate a wave parameter amplifier in a photonic Si\(_3\)N\(_4\) integrated spiral waveguide of 2.0 m length with footprint 3x5 mm. We achieve net gain of 7 dB on-chip and 2 dB fiber-to-fiber in the optical C-band.

**Th2F.2 • 11:00**

Tunable Wavelength Conversion of PDM-PS-64QAM Signals With Arbitrary Input Output Wavelengths Using PPLN-Based Polarization-Diversity Dual-Stage SFG-DFG Process, Takeshi Umeki\(^1\), Takushi Kazama\(^1\), Shimepi Shimizu\(^2\), Takahiro Kishiwakazaki, Koji Enbutsu\(^1\), Takayuki Kobayashi,\(^1\) Yuuta Miyamoto,\(^1\) Kei Watanabe\(^1\),\(^2\) NTT Device Technology Laboratories, NTT Corporation, Japan;\(^3\) NTT Network Innovation Laboratories, NTT Corporation, Japan. We propose a modulation-format-independent tunable wavelength converter that has a PPLN-based polarization-diversity loop configuration with two dual-stage SFG-DFG processes. After confirmation of error-free operation for polarization-scrambled 12.5-Gbit/s OOK signals, wavelength conversion of 100-Gbit/s PDM-PS-64QAM signals with arbitrary input and output wavelengths was successfully demonstrated in the C-band.

**Th2F.3 • 11:15**

Ultra-Wideband All-Optical Interband Wavelength Conversion Using a Low-Complexity Dispersion-Engineered SOI Waveguide, Isaac Sackey,\(^1\) Gregor Ronningen,\(^2\) Carsten Schmidt-Langhorst,\(^1\) Robert Elschenr,\(^2\) Md Mahasin Khan,\(^2\) Hidenobu Muranaka,\(^1\) Tomoyuki Kato,\(^1\) Shun Okada,\(^1\) Toshiyuki Yamamoto,\(^1\) Yu Tanaka,\(^1\) Takashi Hoshida,\(^1\) Colja Schubert,\(^1\) Ronald Freund,\(^1\) Technische Universität Berlin, Germany;\(^2\) Fraunhofer-Institut für Nachrichtentechnik Heinrich-Hertz-Institut HHI, Germany;\(^1\) Fujitsu Laboratories Ltd., Japan. We experimentally present a low-complexity dispersion-engineered all-optical wavelength-converter using a photonic integrated circuit based on SOI waveguide. We achieve a single-sided conversion bandwidth of ~35 nm from C- to S-band, and successfully transmit a converted 1-channel 32-GBd single-polarization QPSK S-band data over a 100-km SMF link.

**Th2G.1 • 10:45**

Versatile, All-Diamond Scanning Probes for High-Performance Nanoscale Magnetometry, Gediminas Seniutinas,\(^1\) Marcelo Gonzalez,\(^2\) Brendan Shields,\(^2\) Felipe Favaro de Oliveira,\(^2\) Patrick Maletinsky,\(^2\) \`Ohami AG, Switzerland;\(^3\) Université Basel, Switzerland. In recent years, probing magnetic field and magnetization of materials at the nanoscale has received significant attention as fields such as MRAM and 2D materials evolve. To deliver on this, scanning NV microscopy has been developed and the advances of this technique will be explored here.

**Th2G.2 • 11:00**

Single-Photon Storage in a Ground-State Vapor Cell Quantum Memory, Gianni C. Buser,\(^1\) Roberto Mottola,\(^1\) Björn Cotting,\(^2\) Janik Woiters,\(^1\) Philipp Treutlein,\(^1\) \`Departement Physik, Universitat Basel, Switzerland;\(^2\) Inst. of Optical Sensor Systems, Deutsches Zentrum für Luft- und Raumfahrt eV, Germany;\(^3\) Inst. für Optik und Atomares Physik, Technische Universität Berlin, Germany. We demonstrate storage and retrieval of SPDC generated photons in a ground-state Rb vapor cell memory, successfully maintaining the single-photon character of the retrieved light. Our platform of single-photon source and atomic memory is attractive for future room-temperature quantum networks operating at high bandwidth.

The model of photonic devices has been evolving from standard packaging to photonic integrated circuits with more efficient and low-cost coupling solutions, compatible for ultra-dense integration. Multiple developments have been done on photonic integrated circuits, either fully on InP platforms mainly for active devices (lasers, high-speed modulators, photodiodes, ...), or with Silicon Photonics (passive devices, high-speed modulators, photodiodes, ...). But to make the best of both platforms in terms of performances and economic model, many laboratories or companies develop hybrid integration of III-V materials and Silicon-based devices (with Si, SiN, or SiO\(_2\) waveguides).

This workshop will focus on the solutions for this hybrid integration, and will present the different technologies to couple light from III-V material to Si-based waveguides. Firstly, heterogeneous integration where III-V lays directly on top of Si-based waveguides with evanescent coupling. Secondly hybrid integration, where the III-V device is butt-jointed to Si-based waveguides, with various alignment techniques and waveguiding approaches. Thirdly, it will present emerging technologies still in development, their challenges and potential, such as transfer printing or direct growth in Si. The comparison will not only be on the technical / performances point of view, but as well on the business aspects, by analysing the business model, versatility and compatibility with multiple suppliers or external foundries, process tolerance to improve yield and costs. Presenters will explain what drove their choices, what are their main applications today and how they foresee future evolutions.

See page 21 of this programme for a list of speakers and topics for this Symposium.
We experimentally demonstrate 12.8 Tbps optical interconnect for a spine-leaf datacenter network with spatial channel connectivity. Rubin S. Luis1, Benjamin J. Putnam2, Georg Rademacher3, Satoshi Shinoda4, Tetsuya Hayashi5, Tetsuya Nakashita6, Yuki Saito1, Tetsu Marishima7, Hideaki Funakawa8, National Inst of Information & Comm Tech, Japan; 9Optical Communications Laboratory, Sumitomo Electric Industries Ltd, Japan. We experimentally demonstrate 12.8 Tbps optical interconnects using an 8-core or two 4-core multicore fibers with 64×200 Gb/s PAM-4 lanes implementing SDM spine-leaf datacenter network topologies. We evaluate a conventional topology with 12.8 Tbps interconnects and the use of low-loss optical cross-connects for spatial channel connectivity.

12.8 Tbps SDM Optical Interconnect for a Spine-Leaf Datacenter Network with Spatial Channel Connectivity, Rubin S. Luis, Benjamin J. Putnam, Georg Rademacher, Satoshi Shinoda, Tetsuya Hayashi, Tetsuya Nakashita, Yuki Saito, Tetsu Marishima, Hideaki Funakawa, National Inst of Information & Comm Tech, Japan; Optical Communications Laboratory, Sumitomo Electric Industries Ltd, Japan. We experimentally demonstrate 12.8 Tbps optical interconnects using an 8-core or two 4-core multicore fibers with 64×200 Gb/s PAM-4 lanes implementing SDM spine-leaf datacenter network topologies. We evaluate a conventional topology with 12.8 Tbps interconnects and the use of low-loss optical cross-connects for spatial channel connectivity.
High-Bandwidth Photodiodes on Silicon Nitride Supporting Net Bitrates in Excess of 350 Gbit/s. Dennis Maes1, Qian Hu1, Robert Borkowski2, Yannick Lefèvre3, Gunther Roelkens2, Sam Lemey1, Emilien Peytavit1, Bart Kuyken1, ’Ghent Univ., Belgium; ’Institut d’Electronique de Microélectro- nique et de Nanotechnologie, France; ’Laboratoire de Physique des Lasers Atomes et Molecules, France. By means of micro-transfer-printing, we bring high-speed UTC photodiodes to a SiN-platform. These waveguide-coupled photodiodes show a responsivity of 0.3 A/W and a bandwidth of 155 GHz. We further demonstrate that direct photomixing at 300 GHz is possible and enables data rates up to 128 Gbit/s.

A Monolithically Integrated Tunable Comb Source and Filter, John McCarthy1, Maryam Shayesteh1, Mohammad Deraki1, Frank Peters2, ’Lyndall National Inst., Ireland; ’Univ. of Southampton, UK. Modern optical networks employ hundreds of lasers that fill up the limited bandwidth. Optical frequency comb sources (OFCs), can potentially reduce or eliminate the use of guard bands by creating coherent superchannels with a precise and stable frequency. In this paper we demonstrate a monolithically integrated comb source which is integrated with a filter with the intent to be used as a de-multiplexer.

Passively Aligned Flip-Chip Laser Diodes Using Multi-Axial Slide-Stop Guided Design and Laser Assisted Bonding (LAB) on a CMOS-Based Optical Interposer, Simon Goh1, Boaochang Xu1, Yu Zhang1, Chun Fei Siah1, Bo Zhao1, Rappal Sebastian1, James Lee1, Suresh Venkatesan1, Aaron Thean1, Yeow Kheng Lim1, ’POET Technologies, Singapore; ’National Univ. of Singapore, Singapore; ’ASML Amica, Germany. The incorporation of rectangular slide-stop structures improves post-bond accuracy by 1.6X achieving a best-in-class relative axial offset of 0.13μm. High-precision bonder with laser-assisted bonding capability enables heterogeneous integration of optical components with higher packing density due to a small heat-affected zone radius of 280μm.
Th2A.7 • 12:15
Core-to-Cladding Ratio-Optimized L-Band Coupled 12-Core Fibre Amplifier With the Highest Power Conversion Efficiency.
Taiji Sakamoto¹, Ryota Imada¹, Shinichi Aozasa¹, Kazuhide Nakajima¹; ²NTT Access Service Systems Laboratories, Japan.
We reveal that the core-to-cladding ratio (Rcc) dependence on the power conversion efficiency (PCE) in cladding-pumped multi-core fibre (MCF) amplifiers differs depending on the operating bandwidth. We obtain the highest PCE from the reported cladding-pumped L-band coupled-MCF amplifiers, 5%, with a fabricated Rcc-optimized 12-core amplifier.

Th2D.4 • 12:15
Wideband QAM-OFDM With Hybrid Integrated InP-Si₃N₄ Tunable Laser Source for Short-Reach Systems,
Lakshmi Narayanan Venkatasubramani¹, Devika Dass¹, Amol Delmade¹, Chris Riefelzen², Douwe Geuzebroek², Liam P. Barry¹; ¹Dublin City Univ., Ireland; ²LioniX International BV, Netherlands.
We demonstrate a record high transmission rate of 160 Gbps with 32 GHz 32QAM and 40 GHz 16QAM OFDM signal (over C-band) using a wavelength-tunable InP-Si₃N₄ laser source for short-reach application. We successfully show the performance is within the standard FEC limits.
Th2E.6 • 12:15
Photodetectors for Classic and Quantum Communication With 39 GHz Bandwidth and 66% Quantum Efficiency, Tobias Beckerwerth1, Trung Thanh Tran1, Sven Mutschall1, Patrick Runge1, Martin Schell1,2,1Fraunhofer Heinrich Hertz Inst., Germany; 2Physics, Technische Universität Berlin Fakultät II Mathematik und Naturwissenschaften, Germany. We present a coherent receiver chip based on flipped uni-travelling carrier (UTC) photodiodes. The UTC photodiodes allow for better linearity with up to 1.2 dBm RF output power and a bandwidth of 39 GHz. By flipping the active structure, the quantum efficiency is maximized for QKD applications.

Th2F.7 • 12:15
Demonstration of a Single-Mode Expanded-Beam Connectorized Module for Photonic Integrated Circuits, Karnil Gradkowski1, David Stegall1, David Mackey2, Alan Naughton3, Terry Smith3, Peter O’Brien1,1Photonics Packaging, Tyndall National Inst., Ireland; 2CRML, Physical Sciences, 3M, USA; 3mBryonics, Ireland; 4International Electronic Manufacturers Inst., USA. We present a pluggable photonic module for data centre and communication applications. We use micro lenses to expand the single mode beam between the fiber array cable and the photonic chip. We show high remating reproducibility and losses of 3 dB per coupler.
Using a stochastic model, we report a novel, red-detuned, 38 dB gain E-Band Bismuth-Doped Fiber Amplifier, Alexandr I. Donodin, Vladimir Dvoryin, Engar Manuylovič, Mikhail Melkumov, Valeriy Mashinsky, Sergei Turystin, Aston Univ., UK; Ke˘naucz cen ter volokonnoj optiki imeni E M Dianov Rossia˘skoj akademii nauk, Russian Federation. We experimentally demonstrate a novel single-stage bismuth-doped fiber amplifier with record E-Band 38 dB gain and 4.5 dB NF operating from 1384 nm to 1484 nm. The amplifier features 28% power conversion efficiency and 3 dB gain bandwidth of 74.7 nm.

Impact of Pump Phase Modification on Fibre Optical Parametric Amplifier Performance for 16-QAM Signal Amplification, Mariia Bastamova, Vladimir Gordienko, Andrew Ellis, Aston Univ., UK. We examine impact of fibre optical parametric amplifier pump phase modification on signals complex amplitude via simulations. We find that in most practical scenarios the required SNR penalty for 16-QAM signals can be less than 0.1 dB at BER of 0.03.

Impact of Splice Loss on Inter-Core Crosstalk in Bidirectional Multi-Core Fibre Transmission and Its Estimation Method, Atsushi Nakamura, Yusuke Koshikiga, NTT Corporation, Japan. We clarify how splices affect inter-core crosstalk in bidirectional transmission systems using uncoupled multi-core fibres. We also propose a method based on optical time domain reflectometry for estimating the impact of splices on the crosstalk in bidirectional systems.

Variable Mode-Dependent-Loss Equalizer Based on Silica-PLC for Two-LP-Mode Transmission, Takayoshi Man, Takeshi Fujisawa, Junji Sakamoto, Yoko Yamashita, Taiji Sakamoto, Iyoja Imada, Iyoja Ima, Takatori Sato, Kei Watanabe, Ryoiichikasahara, Toshikiashishimoto, Kunimasa Sato, KuzuhiedeNakajima, Access Network Service Systems Laboratories, NTT Corporation, Japan. We present a low loss silica PLC based mode dependent loss equalizer with a 2.5 dB variable range. A variable differential modal gain equalization in a two-LP-mode EDFA was demonstrated over the entire C-band for the first time.

A Novel High Speed Directly Modulated Dual Wave- length 1.3 µm DFB Laser for THz Communications, Xuyuan Zhu, Xiaobo Li, Jing Guo, Zhenyu Li, Lingjuan Zhao, Wei Wang, Song Liang, CAS Inst. of Semiconductors, China. We report a novel dual wavelength 1.3 µm DFB laser which has an over 26 GHz modulation bandwidth for THz communications. In dual wavelength working mode, NRZ data modulations at up to 50 Gb/s have been demonstrated successfully.

All-Optical Switching Using a Photonic Crystal Molecule with Asymmetric Fano Lineshape, Quentin Saudan, Dagmawi A. Bekele, Meng Xiong, Kresten Yvind, Jesper Mark, Michael Galili, Department of Electrical and Photonics Engineering, Danmarks Tekniske Universitet, Denmark. We report 10 Gbps all-optical switching using a photonic molecule based on two lattice-shifted coupled photonic crystal nanocavities in Indium Phosphide. The process is enhanced by the asymmetric Fano resonance lineshape leading to 0.4 dB OSNR penalty at error rates smaller than 10^-9 with switching energies as low as 19.5 fJ/bit or 39 fJ/pulse.
Fully Integrated Silicon Photonic Circuit Technology With SiN Passives, Ge Photodetectors and III-V/Si SOAs, Martin Peyroux; Jason Mak; Torrey Thessen; Kevin Froberger; Florian Denis-Le-Coarer; Zheng Yong; Laurent Milloir; Marylise Marchenay; Frédéric Mazur; Yannis Le Guennec; Christophe Jany; Joyce K.S. Poon; Sylvie Menezo; Scint! Photonics, France; Grenoble Images Parole Signal Automatique, France; Commissariat a l’énergie atomique et aux énergies alternatives Laboratoire d’électronique et de technologies de l’information, France; Univ. of Toronto, Canada; Max Planck Inst. of Microstructure Physics, Germany. We present for the first time a fully integrated silicon photonic circuit technology. III-V on Si amplifiers are monolithically integrated at the backside of advanced silicon photonic wafers comprising SiN passive devices, Si based phase shifters and Ge waveguide-photodetectors.

We demonstrate the optical phase conjugation technique using a silicon waveguide fabricated by standard multi-project-wafer processes with ultralow loss of 0.285 dB/cm, high conversion efficiency of -8 dB and evaluate the performance with a 20 Gb/s QPSK signal.

Experimental Demonstration of an All-Optical 2-bit Address Router Look-Up Table, Theodoros Moschos; Abdallah Ali; Long Zhang; Mengfei Ding; Shujun Liu; Baobao Chen; Zhihuan Ding; Gangmin Li; Yawei Xie; Daoxin Dai; ‘Aston Univ., UK; Zhejiang Univ., China. We demonstrate the optical phase conjugation technique using a silicon waveguide fabricated by standard multi-project-wafer processes with ultralow loss of 0.285 dB/cm, high conversion efficiency of -8 dB and evaluate the performance with a 20 Gb/s QPSK signal.

1 x 5 Silicon Nitride MEMS Optical Switch, Suraj Sharma; Niharika Kohli; Michael Ménard; Frédéric Nabi; École de technologie supérieure, Canada; Canadian Microelectronics Corp, Canada. We demonstrate the first 1x5 electrostatic MEMS optical switch with silicon nitride waveguides that combines analog and digital control. It achieves average insertion losses between 2.2 dB and 5.39 dB for the five switching channels and operates over a wavelength range of 85 nm.

Reception of Frequency-Coded Synapses Through Fabry-Perot SOA-REAM Integrating Weighting and Detection Functions, Margareta Vania Stephanie; Florian Hanuza; Nemanja Vokic; Winfried Bockletner; Michael Waltl; Tibor Grassler; Bernhard Schrenk; Inst. for Microelectronics, TU Wien, Austria; AIT Austrian Inst. of Technology, Austria. We experimentally demonstrate a synaptic receptor for 2.5 Gb/s frequency-coded signals, functionally integrating weighting and single-ended photodetection based on a Fabry-Perot (FP) type semiconductor optical amplifier (SOA) monolithically integrated with a reflective electro-absorption modulator (REAM). Comparison is made with a micro-ring assisted receptor.

Enabling Optical Modulation Format Identification Using an Integrated Photonic Reservoir and a Digital Multiclass Classifier, Guillermo von Hüfendiek; Gregor Ronninger; Pooyan Safari; Isaac Sackey; Rijil Thomas; Enes Seker; Piotr Cegelski; Stephan Suckow; Max Lemme; David Staahl; Sarah Masaad; Emmanuel Goossens; Peter Bienstman; Colja Schubert; Johannes Karl Fischer; Ronald Freund; Fraunhofer-Institut fur Nachrichtentechnik Heinrich-Hertz-Institut, HHI, Germany; Technische Universität Berlin, Germany; AMO GmbH, Germany; Rheinisch-Westfälische Technische Hochschule Aachen, Germany; ID Photonics GmbH, Germany; Universität Gent, Belgium. We numerically show modulation format identification in the optical domain using silicon-on-Insulator-based Photonic-Integrated-Circuit (PIC) reservoir. We fabricate the reservoir’s building-blocks and use the experimental results to model the PIC layout. Identification of 32 Gbd single-polarization signals of QOK, PAM4, BPSK and QPSK is successfully achieved.

Ultra-Fast Optical Switching Using Differential Control Method, Kohei lino; Tomohiro Kita; Department of Applied Physics, Waseda Daigaku Riko Gakuin, Japan. A differential control method was applied to a thermo-optic MZI optical switch loaded with MMI phase shifters capable of high-speed, low-power-consumption switching operation. The obtained switching time was 26 ns for T1 and 20 ns for Tm, extremely fast optical switching operation has been demonstrated.

High-Efficiency Optical Phase Conjugation in a Single Ultra-Low-Loss Silicon Waveguide for Nonlinearity Compensation, Shihan Hong; Mingming Tan; Andrew Ellis; Abdallah Ali; Long Zhang; Mengfei Ding; Shujun Liu; Baobao Chen; Zhihuan Ding; Gangmin Li; Yawei Xie; Daoxin Dai; ‘Aston Univ., UK; Zhejiang Univ., China. We demonstrate the optical phase conjugation technique using a silicon waveguide fabricated by standard multi-project-wafer processes with ultralow loss of 0.285 dB/cm, high conversion efficiency of -8 dB and evaluate the performance with a 20 Gb/s QPSK signal.

Experimental Demonstration of an All-Optical 2-bit Address Route Look-Up Table, Theodoros Moschos; Abdallah Ali; Long Zhang; Mengfei Ding; Shujun Liu; Baobao Chen; Zhihuan Ding; Gangmin Li; Yawei Xie; Daoxin Dai; ‘Aston Univ., UK; Zhejiang Univ., China. We demonstrate the optical phase conjugation technique using a silicon waveguide fabricated by standard multi-project-wafer processes with ultralow loss of 0.285 dB/cm, high conversion efficiency of -8 dB and evaluate the performance with a 20 Gb/s QPSK signal.

SC3 – Photonic Integrated Circuits, Assemblies & Packaging – Posters

L-Band Mode and Wavelength Conversion in a Periodically Poled Lithium Niobate Ridge Waveguide, Siqing Liang; Yongmin Jung; Kyle Bottrell; Peng Zhang; David Richardson; Lin Xu; Optoelectronics Research Centre, Univ. of Southampton, UK; hiSilicon Optoelectronics Co., Ltd., China. We present simultaneous mode and wavelength conversion over wavelengths from 1570 nm to 1610 nm based on internal difference frequency generation in a periodically poled lithium niobate ridge waveguide. A conversion efficiency of -10.7 dB is observed owing to the high quadratic nonlinearity.

L-Band Mode and Wavelength Conversion in a Periodically Poled Lithium Niobate Ridge Waveguide, Siqing Liang; Yongmin Jung; Kyle Bottrell; Peng Zhang; David Richardson; Lin Xu; Optoelectronics Research Centre, Univ. of Southampton, UK; hiSilicon Optoelectronics Co., Ltd., China. We present simultaneous mode and wavelength conversion over wavelengths from 1570 nm to 1610 nm based on internal difference frequency generation in a periodically poled lithium niobate ridge waveguide. A conversion efficiency of -10.7 dB is observed owing to the high quadratic nonlinearity.

136-Gbit/s Optical QAM-OFDM Receiver With MZI DeMux Waveguide Ge Photodiode for O-Band SMF Link, Yu-You Chen; Kuo-Fang Chung; Jyun-Yang Su; Chih-Hsin Cheng; Tien-Tsong Shih; Ding-Wei Huang; Gong-Ru Lin; Graduate Inst. of Photonics and Optoelectronics, and Department of Electrical Engineering, National Taiwan Univ., Taiwan; Research Center for Advanced Science and Technology, Univ. of Tokyo, Japan; Department of Electronic Engineering, National Kaohsiung Univ. of Science and Technology, Taiwan; Tektronix-NTU Joint Research Center, National Taiwan Univ., Taiwan. By using a Ge lateral p+/p/n++/p++ junction waveguide photodiode integrated with a dualstage Mach-Zehnder interferometric waveguide demultiplexer for 4-channel CWDM SMF network at 16, the error-free receiving of the broadband optical QAM-OFDM data stream at 136 Gbit/s within 34 GbAud bandwidth is successfully demonstrated.
Tu5.24 Energy-Efficient Silicon Optical Phased Array with Ultra-Sparse Nonuniform Spacing, Huaqing Qiu1, Yong Liu1, Xiaoxiang Meng1, Xiaowei Guan2, Yunchong Ding1, Hao Hui1, Technical Univ. of Denmark, Denmark; 1Jiaoxing Key Laboratory, Jiaxing Key Laboratory of Photonic Sensing & Intelligent Imaging, China. We experimentally demonstrate an ultra-sparse 120-channel silicon optical phased array with a large aperture size of 6 mm × 5 mm. A 162° field of view was achieved with a total power consumption of 0.47 W and thermo-optic power efficiency of 3.1 mW/°C.

Tu5.27 Investigating the Performance and Suitability of Neural Network Architectures for Nonlinearity Mitigation of Optical Signals, Vensgernanti Dsilva1, Isaac Sasekky2, Gregor Rönniger1, Guillermo von Hünefeld1, Binoy Chacko1, Ronald Freund1, Colja Schubert1, Technische Universität Berlin, Germany; 1Fraunhofer-Institut für Nachrichtentechnik Heinrich-Hertz-Institut HHI, Germany. We compare three different neural network architectures for nonlinearity mitigation of 32 Gbd OOK and QPSK signals after transmission over a dispersion-compensated link of 10-km SSMMF and 10-kmDCF. OSNR gains up to 2.2 dB were achieved using reservoir networks, suitable for fast training.

Tu5.28 Low Complexity Joint Neural Network Equalizer in a 248 Gbit/s VSB PS-PAM8 IM/DD Transmission System, Chen Wang1, Kaihui Wang1, Yuxuan Tan1, Junjie Ding1, Bohan Sang1, Feng Wang1, Bowen Zhu1, Miao Gong1, Ken Zhou1, Jiangn Yu1, Fujian Univ., China. We propose a novel joint neural network equalizer in a 248 Gbit/s VSB PS-PAM8 transmission system at the C-band. The proposed joint neural network equalizer outperforms the conventional neural network equalizer with significant MACC calculation complexity deduction.

Tu5.29 Compressed Look-up Table-Based Implementation Friendly MLSE Equalizer for C-Band DSB IM/DD Transmission, Zhue Chen1, Xiaoxiao Dari2, Junyan Nie1, Shenniao Zhan1, Yahao Zhou1, Jing Zhang1, Ying Qiu2, Ming Luo2, Qi Yang1, Lei Deng1, Mengfan Cheng1, Lilin Yi2, Chuandong Li1, Hamid Ebrahimzadeh1, Alireza Sharafedin2, Junjie Ding1, Binoy. A probabilistic signaling technique with balanced state of polarization is introduced, and its performance is analyzed for coherent dispersion-managed links. Simulation results show stable gains over the number of transmission spans and a positive effect on legacy WDM channels.

Tu5.30 Asymmetric Self-Coherent Detection with Mitigated SSBI Enhancement Using Partial pre-compensation, Xueyang Li1, Honglin Ji1, Lulu Liu1, Shanghai Cheng Wang1, Zhixue He1, Weisheng Hu1, Peng Cheng Laboratory, China. We propose a partial pre-compensation scheme to mitigate the SSBI enhancement induced by the non-ideal receiver response of double-sideband self-coherent detection systems. 1.2 dB enhancement of the power sensitivity is achieved based on optimized partial pre-compensation in a chromatic dispersion-based asymmetric self-coherent detection system.

Tu5.31 Noise Analysis for the Communication System Using High-Speed DAC and ADC, Tong Ye1, Xiaofei Su1, Chengwu Yang1, Jingshan Li1, Zhenning Tao1, Hisao Nakashima1, Takeshi Hoshida1, Fujitsu R&D Center, China; Fujitsu Ltd., Japan. System performance dominated by the high-speed DAC and ADC imperfections is experimentally investigated. Modelling based on ENOBs and/or SINADs turns out to overestimate the performance while orthogonal additive noise model, which has low correlation with the signal PAPR, is shown to enjoy higher accuracy.

Tu5.32 Spatially Disaggregated Modelling of Self-Channel NLI in Mixed Fibers Optical Transmission, Emanuelle E. Virgilio1, Andrea Castoldi1, Andrea D’Amico1, Stefano Strauß1, Rudi Bratožič1, Francesco Martínez Rodríguez1, Andrea Bovic1, Rosanna Pastorelli1, Vittoria Cumi1, Politecnico di Torino, Italy; 1SM-Optics, Italy; 1Links Foundation, Italy. We simulate and observe the build-up of coherence in self-channel interference. We propose a spatially disaggregated model for non-uniform links with uncompensated and compensated spans. We show that the correlation coefficient can be described by a unique curve.
We propose and experimentally present a phase-stabilized metrological optical frequency pruning DNN-NLE with 24%-lower complexity outperforms GBd truncated PS-64QAM utilizing 75%-sparsity pruning DNN-based nonlinear equalization. Results show that our pruning DNN-NLE with 24%-lower complexity outperforms Volterra NLE by 20% reach improvement.

Monitoring of Generalized Optical Signal-to-Noise Ratio Using in-Band Spectral Correlation Method, Cholong Hahn1, Junho Chang1, Zhiping Jiang1; Huawei Technologies Canada, Canada. We propose and experimentally demonstrate low-cost correlation methods for monitoring the generalized optical signal-to-noise ratio in the middle of link. For the first time, self-phase modulation noise can be directly monitored.

We propose individual error correction techniques for headers and data to adapt to various transmission requirements of data. We also experimentally demonstrate lossless transmission via 100-GB/s optical interfaces up to 90 km with less than 1.5% increase in latency due to the characterization through a successful transmission of a 75-Gb/s PCE-256QAM signal with a 1.05-Tb/s raw data rate.

We propose a simple but efficient method to simultaneously characterize the frequency-resolved IQ and polarization imbalance by a single-shot measurement for coherent transceivers based on the simple inter-channel response ratio. We demonstrate the characterization through a successful transmission of a 75-Gb/s PCS-256QAM signal with a 1.05-Tb/s raw data rate.

We present a phase-stabilized metrological optical frequency dissemination network spanning over 456 km, multiplexed into the L-band ITU-T channel 7 of the Swiss academic optical network. Our solution provides efficient shared use of existing fibers for ultra-precise time and frequency signals into the L-band ITU-T channel 7 of the Swiss academic dissemination network spanning over 456 km, multiplexed into the L-band ITU-T channel 7 of the Swiss academic optical network. For the first time, self-phase modulation noise can be directly monitored.

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Tu5.50 Field Trial of Remotely Controlled Smart Factory Based on PON Slicing and Disaggregated OLT, Yong- Wook Ra, Chan-Sung Park, Kyoungho Hwang, Kyeeong Hwan Doo, Kwang Ok Kim, Hanyub Lee, Taek Chung, Jae-Sheung Shin, Hwan Seok Chung; Electronics and Telecommunications Research Inst., Korea (the Republic of); 4HFR networks, Korea (the Republic of). Field trial of remotely controlled 5G smart factory was demonstrated by PON slicing and disaggregated OLT, for the first time. PON slicing is realized by interworking of SADIS, VOLT, and slicing app in vPON.

Tu5.53 Experimental Demonstration of a Novel OFDM-NOMA Bit and Power Loading Algorithm for Hybridunicast and Broadcast Transmission in Cooperative VLC Systems, Chengyu Yu, Geyang Wang, Shuhua Song, Jian Zhao; School of Electronic and Information Engineering, South China Univ. of Technology, China. We propose a novel OFDM-NOMA bit and power loading algorithm for hybrid unicast and broadcast downlink and demonstrate in 1.1-1.9GHz cooperative VLC experiments that the proposed algorithm outperforms conventional OFDM-NOMA, DFT-S-OFDM-NOMA, and OCT-NOMA regardless of the unicast/broadcast data rates and channel conditions.

Tu5.54 Programmable Anti-Logarithm Linearization Circuits (PACL) for Self-Adaptive Signal-to-Noise Ratio Optimization in Photovoltaic Visible Light Communications, Shuyan Chen, Liqiong Liu, Lian-Kuan Chen; The Chinese Univ. of Hong Kong, Hong Kong. A programmable anti-logarithm linearization circuit (PACL) for linearizing photovoltaic modules is proposed and implemented. With the investigation of an optimal number of diodes required in PACL under different scenarios, a BER reduction from $1.4 \times 10^{-3}$ to $8.2 \times 10^{-4}$ is achieved under 1000 lux with self-adaptation.

Tu5.55 Complexity-Reduction for the Digital-Filtered AWGR-Based 2D IR Beam-Steered OWC System by Using Non-Integer Oversampling, Luyan Chen, Chin Wan Ong, Jeffrey Lee, Xuebing Zhang, Ton Koonen; Electrical Engineering, Technische Universität Eindhoven, Netherlands; EFFECT Photonics B.V., Netherlands. Digital Nyquist filtering improves the capacity of our 12.5-GHz channel-spaced 6-GHz bandwidth-limited AWGR-based 2D infrared beam-steered OWC system but introduces additional complexity. Experiments demonstrate the practicability of non-integer oversampling at 1.1x symbol rate with root-raised-cosine filtering to reduce data converter sampling rate and power consumption.

Tu5.56 Virtual-Carrier-Assisted 64QAM Millimetre-Wave Signal Generation Using Low-Resolution Digital-to-Analog Converter, Chunmiao Huang, Hugui Jin, Mengfan Cheng, Qi Yang, Deming Liu, Ming Tang, Lei Deng; Huazhong Univ. of Science and Technology, China. We experimentally demonstrate a radio frequency digital resolution enhancer (RF-DRE) to mitigate quantization noise of 30 GHz 12.5 Gbaud 64QAM signal. By using RF-DRE, BER of 4-bit DAC quantized signal is improved from 6.88e-3 to 1.49e-3, and 5-bit DAC exhibits similar performance to 8-bit DAC.

Tu5.57 Microwave OFDM Quantum-Noise Randomized QAM Carrier Generation via Analog IFoF Transmission With a DML, Ken Tanizawa, Fumio Futami, Tamagawa Univ., Japan. We demonstrate an IM/DD IFoF transmission system using a DML for the delivery and generation of 4.25-Gbit/s OFDM quantum-noise randomized QAM carrier at an IF of 1.875 GHz. The simplified setup achieves truly random quantum-noise signal masking for preventing interception while maintaining high signal quality.

Tu5.58 Bit and Power Loading Algorithm for Hybrid Unicast and Broadcast Transmission in Cooperative VLC Systems, Chengyu Yu, Geyang Wang, Shuhua Song, Jian Zhao; School of Electronic and Information Engineering, South China Univ. of Technology, China. We propose a novel OFDM-NOMA bit and power loading algorithm for hybrid unicast and broadcast downlink and demonstrate in 1.1-1.9GHz cooperative VLC experiments that the proposed algorithm outperforms conventional OFDM-NOMA, DFT-S-OFDM-NOMA, and OCTP-OFDM-NOMA regardless of the unicast/broadcast data rates and channel conditions.

Tu5.59 DeepDefrag: Spatio-Temporal Defragmentation of Time-Varying Virtual Networks in Computing Power Network Based on Model-Assisted Reinforcement Learning, Huangxu Ma, Jiahei Zhang, Zhiquin Gu, Hao Yu, Tian Taleb, Yuefeng Ji, Beijing Univ. of Posts and Telecommunications, China; Center for Wireless Communications, Oulu University, Finland. We propose DeepDefrag, a model-assisted reinforcement learning for spatio-temporal defragmentation of time-varying virtual networks in a cross-layer optical network testbed, which realizes the efficient utilization of computing nodes and lightpaths by co-optimizing scheduling and embedding with fragment matching, reduces >13.5% cost of computing power network.

Tu5.60 A Novel Approach for Joint Analytical and ML-Assisted GSNR Estimation in Flexible Optical Network, Farhad Arpanaee, Behnam Shariati, Pooyan Safari, Mehdi Ranjbar, José Alberto Hernández, Andrea Carena, Johannes Karl Fischer, David Larabett; Univ. Carlos III of Madrid, Spain; Fraunhofer Inst. for Telecommunications, Germany; Politecnico di Torino, Italy; Cisco Systems Inc, Italy. We propose a novel approach to perform QoT estimation relying on joint exploitation of machine learning and analytical formula that offers accurate estimation when applied to scenarios with heterogeneous span profiles and sparsely occupied links. Our approach significantly outperforms the widely used lightpath-level QoT estimation.

Tu5.61 SONIC-Based Network Operating System for Open Whitebox Optical Transport Equipment, Zheng Weitang, Xiaodong Gu, Xin Lei, Chongjin Xie, Yang Zhang, Xiaosheng You; Alibaba Group, China; Alibaka Group, USA; Accelink Technologies, China. In this paper, we propose and demonstrate a SONIC-based network operating system for open whitebox optical transport equipment including optical transponders, amplifiers and protection switches. An optical network linecard abstraction interface is introduced to create a unified and vendor neutral linecard abstraction layer.
Tu5.62 Time-Aware Deterministic Bandwidth Allocation Scheme for Industrial TDM-PON, Chen Su1, Jiawei Zhang2, Hao Yu2, Tarik Taleb2, Yuefeng Ji1,2, Beijing Univ. of Posts and Telecommunications, China; 2Öulun Yisipso Tieto- ja sähkötieteen tiedekunta, Finland. For Industrial Internet with TDM-PON, we propose a time-aware deterministic bandwidth allocation (TA-DBA) scheme that allocates proper transmission windows based on flow arrival time and cycle. Simulation results show that TA-DBA can achieve deterministic transmission, and the average bandwidth efficiency is 20.4% higher than FBA.

Tu5.63 Routing and Spectrum Assignment in SDN PON Supporting Low-Latency Traffic Using Reinforcement Learning, Abdenour Ben Terki1, Banana Aithani2, Mohsen A. Kazemzadeh2, Abdennour Ben Terki1, Department of Computer Science, Univ. of L’Aquila, Italy; 2Universiteit Hasselt, Belgium; 3Scuola Superiore Sant’Anna, Italy. Routing and spectrum assignment strategies – exploiting Reinforcement Learning (RL) – are investigated for multi-band optical networks. Generalized Signal to Noise Ratio accounting for Stimulated Raman Scattering is estimated driving modulation format selection. Simulations show that RL may significantly reduce blocking probability (e.g., one order of magnitude).

Tu5.64 Slice Management in SDN PON Supporting Low-Latency Services, Carlo Centonze2, Andrea Manotta1, Dajana Casoni2, Fabio Graziosi2, Andrea Sambra2, Luca Valcarenghi2, Chris Bernard3, Infinera Corp, Portugal; 2Infinera Corp, Germany; 3TeCIP, Scuola Superiore Sant’Anna, Italy. We study possible slice management strategies in software defined passive optical networks for low latency services. Our results show that reactive slice deployment is able to enforce latency requirements requiring a minimal setup time while increasing network efficiency compared to proactive strategies.

Tu5.65 Leveraging Pointer Network for QoT-Aware Routing and Spectrum Assignment in Elastic Optical Networks, Yusen Chen1, Shifeng Ding2, Chunj-Kit Chan3, The Chinese Univ. of Hong Kong, Hong Kong. We propose a pointer-based networked QoT-aware routing and spectrum assignment scheme that can directly generate lightpaths with high OSNR, without pre-calculated candidates. Simulation results showed that the proposed scheme can significantly reduce the blocking probability while with a good guarantee of the lightpath QoT.

Tu5.66 Channel-Based Approach for a Practical Multi-Period Planning of Elastic Optical Networks, Leonardo Mesquita1, Karicius D. Assis2,3, Raul Almeida4,5,6, Raul Almeida4,5,6, Abdennour Ben Terki1, Universidade Federal de Pernambuco, Brazil; 2Instituto de Telecomunicacoes, Portugal; 3Scuola Superiore Sant’Anna, Italy; 4University of L'Aquila; 5Telecommunications, China; 6Department of Electrical and Computer Engineering, Northwestern Univ., USA. We propose a channel-based approach for designing the elastic optical networks considering a multi-period design. Resultant solutions provide a set of options for practitioners to assist network design choices considering future traffic.

Tu5.67 DV-QKD Coexistence With 1.6 Terabit/s Classical Channels in Free Space Using Fiber-Wireless-Fiber Terminals, Obada Alia1, Andy Schreier2, Rui Wang2,3, Georgia Faulkner2,3, David Pohl1, The Univ. of Oxford; 2Technische Universität München; 3HIGH Performance Network Group, UK; 4Univ. of Oxford Department of Engineering Science, UK; 5H. H. Wills Physics Laboratory, Univ. of Bristol, Quantum Engineering Technology Labs, UK. We experimentally demonstrate for the first time the simultaneous transmission of a COW-based DV-QKD channel and an 8x200 Gbps 16-QAM coherent optical channels, both operating in the C-band over 2.5 m of free space enabled by Fiber-Wireless-Fiber terminals.

Tu5.68 Entangled States in Nd+ Doped Crystals with Fluorite Structure as Qubits, Yuri V. Orlovskii1,2, Ekaterina Vagaeva1,2, Vitaly Fedorovich3,4,5, Vladimir Hrynkov4,5, Inst. of Physics, Tartu Ulikool, Estonia; 2Institut voor Fotoniek en Technologie, Leuven, Belgium; 3High Performance Network Group, UK; 4University of Oxford; 5University of Aegean, Greece. We propose an all-optical cache hierarchy that extends existing optical cache designs with an optical PCM LLC. We design and analyze methods to mitigate PCM’s slow write speed and limited lifetime for 20% execution time reduction and non-volatility.

Tu5.69 Direct Comparison of on-chip Hong-Ou-Mandel Interference of Photon Pairs From Ring Resonators and Straight Waveguides, Jong-Moo Lee1,2,3,4,5, Electronics and Telecommunications Research Inst., Korea (the Republic of); 2Metro-Goldwyn-Mayer; 3University of Oxford; 4ETH Zürich, Switzerland; 5Scuola Superiore Sant’Anna, Italy. We measure on-chip Hong-Ou-Mandel visibility of 80.0% with photon pairs from ring resonators and 98.9% from straight waveguides on a silicon-photon circuit. The ring is tuned to the pump wavelength or not by choice, the ring tuned to the pump wavelength or not by choice, on and off the influence of the ring, respectively.

Tu5.70 Space-Wavelength-Division-Multiplexing-Based Synergetic Transmission in Quantum Key Distribution Coexisting with Classical Communications, Weiwen Kong1, Yongmei Sun1, Xueqin Ren1, Yuelong Gao1, Yongmei Sun1, Xueqin Ren1, Yuelong Gao1, Beijing Univ. of Posts and Telecommunications, China. We discuss the architecture of an all-optical cache hierarchy that extends existing optical cache designs with an optical PCM LLC. We design and analyze methods to mitigate PCM’s slow write speed and limited lifetime for 20% execution time reduction and non-volatility.

Tu5.71 Computing With an All-Optical Cache Hierarchy Using Optical Phase Change Memory as Last Level Cache, Hua Yang1, Theoni Alexoudi1, Chris Vagias1, Nikos Pleros1, Nikos Hardavellas1,2, Department of Electrical and Computer Engineering, Northwestern Univ., USA; 2Department of Informatics, Aristotle University of Thessaloniki, Greece; 3Department of Computer Science, Northwestern Univ., USA. We discuss the architecture of an all-optical cache hierarchy that extends existing optical cache designs with an optical PCM LLC. We design and analyze methods to mitigate PCM’s slow write speed and limited lifetime for 20% execution time reduction and non-volatility.

Tu5.72 Interferometrically Coupled Reconfigurable Racetrack Resonator on Lithium Niobate-on-Insulator Platform, Andreas Maeder1, Fabian Kaufmann1, Giovanni Finco1, David Pohl1, Joint Keller1, Xuyue S. Wang1, Rachel Grange1, ETH Zürich, Switzerland. We exploit a thermo-optically tuned interferometric coupling scheme to relax fabrication tolerances on coupling segments of microresonators in lithium niobate-on-insulator. We achieve extinction ratios up to 34 dB and show tuning of resonance bandwidth between 15 and 45 pm while maintaining extinction above 15 dB.

Tu5.73 Spectro-Temporally Multiplexed Reservoir Computing Based on a Multimode Fabry Perot Laser, Menelao Skontraris1, George Sarantogiu1, Adonis Bogris1, Chris Mesaritakis1, Univ. of Aegean, Greece; 2Panepistemio Dytikes Attikes Schole Mechanikon, Greece. We present numerical results from a spectro-temporal reservoir computing based on a Fabry-Perot laser. By exploring longitudinal modes, we achieved tunable real time processing rate, reaching up to 2.38 GHz for an image classification task with elevated accuracy.
We present a polarization-insensitive...,
High Performance Polarization Rotator-Splitter Based on Si$_3$N$_4$ Waveguide With Relaxed Fabrication Tolerance, Xiaoyang Dai, Lijing San, Yongmei Tang, Gaoyun Lu, John F. Donegan, Weihsu Guo; 3Huazhong Univ. of Science and Technology, China; 2School of Physics and CRANN and CONNECT, The Univ. of Dublin Trinity College, Ireland. A novel polarization rotator-splitter is presented based on Si$_3$N$_4$ platform with relaxed fabrication-tolerance and high-performance. The proposed device is fabricated by standard-photolithography due to the introduced high-asymmetrical directional-coupler, and demonstrates a polarization extinction-ratio $-20$dB with the fabrication-tolerance $\sim 150$nm and polarization conversion-loss $\sim 1$dB across the C-band.

Pre-Fabrication Performance Verification of a Topologically Optimized Mode Demultiplexer Using Deep Neural Networks, Dusan Gostimirovic, Md Mahadi Masnadi, Dan-Xia Xu, Yun Gribnig, Odile Liborain-Ladouceur; 2Department of Electrical and Computer Engineering, McGill Univ., Canada; 1Advanced Electronics and Photonics Research Centre, National Research Council Canada, Canada; 2Digital Technologies Research Centre, National Research Council Canada, Canada. Photonic miniaturization benefits from topological inverse design that favours the use of small, difficult-to-fabricate features. We use machine learning to predict the fabrication of a topologically optimized mode demultiplexer, then re-simulate and validate its optical performance for cost-efficient pre-selection of design prior to fabrication.

Electro-Optical Frequency Comb Generator Based on Electrical and Optical Dual Resonance Enhanced Structure, Hulan Tu, Jia Liu, Haisheng Weng, Qiaoyin Lu, Lirong Huang, John F. Donegan, Weihsu Guo; 2CRANN and AMBER, Trinity College Dublin, Ireland; 3Huazhong Univ. of Science and Technology, China. An electro-optic frequency comb generator based on electrical and optical dual resonance enhanced structure is proposed. The theoretical analysis and experimental measurements demonstrate that the modulation depth of the standing-wave electrode is increased by 2.3 times, and the spectral bandwidth is extended to 1.7 times.

We5.16
Photon Integrated Spatial Mode Controller Based on Thin Film Lithium Niobate, Yunfan Wu, Yudan Zhang, Su Tan, Xiangyang Dai, Qiaoyin Lu, John F. Donegan, Weihsu Guo; 3Huazhong Univ. of Science and Technology, China; 2The Univ. of Dublin Trinity College, Ireland. We demonstrate a compact photonic-integrated spatial mode controller based on arrayed-waveguide-grating (AWG) using the thin-film z-cut lithium niobate platform. The fabricated integrated chip exhibited 100 output channels with intervals of 50 pm. The controlling time is measured less than 0.5 ms for the amplitude control.

We5.17
Characterising the Onset of Lasing Using Interferometric Photon Correlations, Xi Jie Ye, Alvin Leow, Peng Kian Tan, Lijong Shen; 2Center for Quantum Technologies, Singapore; 1Department of Phys.echs, National Univ. of Singapore, Singapore. We present a technique to characterize the onset of coherence in a semiconductor laser diode using interferometric photon correlation measurements. We observe with increasing injection current a transition of light emitted by the diode from chaotic, to a chaotic-coherent light mixture, to coherent.

We5.18
Study of Efficient Photonic Chromatic Dispersion Equalization Using MZI-Based Coherent Optical Matrix Multiplication, Sihe Xing, Guoqiang Li, Ziwei Li, Nan Chen, Jinwen Zhang, Yudan Univ., China. We propose and study an efficient photonic CDE method using MZI-based coherent optical matrix multiplication. It improves the compensation performance by about 60% when the tap-length is limited, and only 50% taps of the theoretical value is needed for photonic CDE with 1-dB penalty.

We5.19
Adapting Routing Algorithms to Programmable Photonic Circuits, Ferre Vanden Kerchove, Xiangteng Chen, Didier Colle, Wim Bogaerts, Maria Pickavet; 2Department of Information Technology, IDLab, Ghent Univ. - IMEC, Belgium; 3Ghent Univ. - IMEC, Photonic Research Group, Department of Information Technology, Gent, Belgium, Belgium; 4Center of Nano and Biophotonics, Ghent Univ., Belgium, Belgium. The ever-increasing size of programmable photonic integrated circuits necessitates the development of specialised routing algorithms, capable of handling different mesh architectures and magnitudes. We develop an algorithm specifically adapted to the unique characteristics of programmable photonic circuits.

We5.20
High-Speed Analog Photonic Computing With Tiled Matrix Multiplication and Dynamic Precision Capabilities for DNNs, George Giamougianis, Apostolos Tsyriklis, Miltiadis Moralis-Pegis, Christos Pappas, Manos Kirtas, Nikolaos Passalis, David Lazovsky, Anastasios Tefas, Nikos Pierogi, Aristotelis Panepistemos Thessalonikes, Greece; 2Center of AI, USA. We demonstrate neuromorphic silicon photonic computing that supports fast input/weight update rates together with dynamic precision capabilities, validating experimentally the classification of the IRIS database set within a two-layer NN with compute speeds up to 50 GHz.

We5.21
16 Channel Tunable and 28 Gbd PAM-4 Modulated DBR-EAM With High Thermal Efficiency, Su IK Park, Jae Hyun Jin, Chul Wook Lee, Ki Soo Kim, Oh Kee Kwon, Kyoung Su Park; 2Jong-In Shim; 1Essence Photonics Inc., Korea (the Republic of), 2Photonics Convergence Components Research Group, Electronics and Telecommunications Research Inst., Korea (the Republic of), 3Department of electronics engineering, Kangwon National Univ., Korea (the Republic of), 4Department of Photonics and Nano-electronics, Hanyang Univ. - Ansan Campus, Korea (the Republic of). We propose an optical waveguide structure which can effectively confine the heat produced by the thin-film heater and fabricate the DBR laser diode integrated with the intensity modulator. Under the 28 Gbd-PAM-4 modulation, the fabricated device shows 16 channel operation with clear eye patterns.

We5.22
Simulation of an Arbitrary Optical Switch on a Dense Programmable Photonic Processor, Ator López, Erica Sánchez, Daniel Perez; 1Universitat Politècnica de València, Spain; 2Pranics programmable photonics, Spain. In this work, we present and compare the performance of two novel simulation approaches to provide the spectral response of an arbitrary switch featuring two different operation modes on a dense, highly-coupled programmable photonic processor.

SC4 • Techniques for Digitally Enhancing Optical Communication – Posters

SC4.23

SC4.24
On the Performance of Super-Symbol PCS-QAM Digital Subcarrier Multiplexing in Coherent Optical Fiber Systems, Trung-Hien Nguyen, Sami Mumtaz, Abel L. Riessgo, Khoa Le Trung, Dylan Le Gac, Manuel Neves; 1Huawei Technologies France, OCT lab., France; 2Insti- tuto de Telecomunicacoes, Univ. of Aveiro, Portugal. We experimentally assess the use of super-symbol (SUP) transmission with different distribution matching methods in a 100 Gb/s PCS-25GQAM digital subcarrier multiplexing system. We achieve 0.1 dB SNR improvement after 900 km, a gain which comes almost for free due to the low complexity of SUP.
We5.29 On the Impact of the Optical Phase Conjugation Solution on the Computational Complexity of Neural Network-Based Equalisers, Diego Arguello Ron1, Karina Nurliybayeva1, mortar2, Kamal-Kian-Kopaei2, Abdallah Ali3, Elena Turitsyna1, Sergei Turitsyn1, Aston Univ., UK. We develop a low complexity complex-valued neural network to compensate the nonlinearity from the transmission of PDM 28 Gbaud 64QAM over 400km of SSFM, by combining midRk optical phase conjugation and pruning.

We5.30 A Parallel Structure for Polar Codes With Adaptive Frozen Set, Hamid Ebrahimzade1, Ali Farsiabi1, Chuandong Li1, zhuohong zhang1, Huawei Technologies Canada, Canada. We propose a parallel structure for polar codes which is suitable for parallel-pipelined decoding. Our proposed structure outperforms the regular polar code with same length by 0.2 to 0.4dB and can achieve the performance of a polar code with a length twice the length of compo- nent codes.

We5.31 Generalized OSNR Penalty Induced by SDM Amplifiers’ Differential Spatial-Lane Gain, Linxian Wang1, Zhiping Jiang1, Huawei Technologies Canada, Canada. The maximum allowed differential spatial-lane gain (DSG) of SDM amplifiers is key information for amplifier designers. We have demonstrated a simplified method based on relative calculations to estimate the impact of DSG under different conditions.

We5.32 Physics-Informed Neural Operator for Fast and Scal-able Optical Fiber Channel Modelling in Multi-Span Transmission, Yuchen Song1, Danshi Wang1, Girir Fan1, Xiaotian Jiang1, Xiao Luo1, Min Zhang1, Beijing Univ. of Post and Telecomun., China;2Department of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong. We propose efficient modelling of optical fiber channel via NLSN-constrained-physics-informed neural operator without reference solutions. This method can be easily scalable for distance, sequence length, launch power, and signal formats, and is implemented for ultra-fast simulations of 16-QAM signal transmission with ASE noise.

We5.33 Nonlinear Interference Noise of Constant-Composition Codes, Reza Rafie Borujeny1, Frank R. Kschischang1; Electrical & Computer Engineering, Univ of Toronto, Canada. A time-domain perturbation model of the nonlinear Schrödinger equation is used to explain (a) why constant-composition codes offer an improvement in signal-to-noise ratio compared with independent and uniform selection of constellation points and (b) why similar gains are obtained using carrier recovery algorithms.

We5.34 A Multi-Threshold Quantization Scheme for Physical Layer Key Distribution, Xiangyu Liu1, Kongni Zhu1, Yajie Li2, Yongli Zhao1, Jie Zhang1, Iupt, China. A multi-threshold quantization scheme is proposed in this paper and compared with the traditional two-threshold quantization scheme. When the correlation coefficient is around 0.95 and above, the use of this scheme is better than two-threshold quantization.

We5.35 Nonlinearity Mitigation in a Semiconductor Optical Am- plifier Through Gain Clamping by a Holding Beam, Josef Demirzioglu1, Romain Brenot2; Alberto Lopez-Riesgo1, Trung-Hien Nguyen1, Nayla El Dahdah2, Antonin Gallet1, Shuq Yu1, Sheherazade Aouizi1, Yann Frignac1, Gabri- el Charlet1; Huawei Technologies France, France. We demonstrate the benefit of gain-clamping in mitigating SOA nonlinear noise through the use of an external optical beam. A nonlinear noise reduction of 2.3 dB is observed through extensive experimental SNR measurements.

We5.36 Comparison of PAM-6 Modulations for Short-Reach Fiber-Optic Links With Intensity Modulation and Di- rect Detection, Tobias Pin1, Thomas Wiesig1, Daniel Pabst1, Talha Rahmani1, Md Sabbir-Bin Hossain1, Nebjosa Stojaovic1, Stefano Calabro1, Norbert Hanik1, Gerhard Kramer1; Technische Universität Munchen Fakultat für Elektrotechnik und Informationstechnik, Germany;2Huawei Technologies Deutschland GmbH, Germany. PAM-6 transmission is considered for short-reach fiber-optic links with intensity modulation and direct detection. Experiments show that probabilistically-shaped PAM-6 and a framed-cros QAM-32 constellation outperform conventional cross QAM-32 under a peak power constraint.

We5.37 Improving Capacity Predictions for Subsea Open Cables Employing Modern Coherent Transceivers, Siddharth Varughese1, Daniel Semnrau1, Domanic Lavrey1, Dermin Yao1, Marc Stephens1, Emilio Bravi1, Mehdi Torbatian1, Pierre Mertz1; Infineera Corporation, USA. We study the effects of modern transceiver technologies such as probabilistic constellation shaping, symbol interleaving, and fiber nonlinearity compensation on subsea cable capacities and describe how their effects can be included in the subsea open cable standard to improve capacity predictions.

We5.38 Expanded Modal Capacity for OAM With Standard 2×2 MIMO, Mai Banawan1, Saytendra K. Mishra1, Anane Goun1, Nathalie Baco1, Xin Guan1, Li Xin Wang1, Sophie Larochelle1, Leslie Rusch1; Department of Electrical and Computer Engineering, Center for Optics, Photonics and Lasers (COPL), Université Laval, Canada;2Tanghua Shenzhen International Graduate School, China;3Canada Research Center, Huawei Technologies Canada, Canada. Standard commercial, electronic 2×2 MIMO can greatly extend modal multiplexing compared to MIMO-free strategies. We experimentally demonstrate the highest bit rates achieved with multiplexing of orbital angular momentum (OAM) modes at 475 Gba/s per wavelength. Our demultiplexing strategies are compatible with commercial solutions.
We5.39
Comparison of Physical Realizations of Multidimensional Voriostat Constellations in Single Mode Fibers, Ali Mirani, K ovendran Vijayaraj, Shen Li, Zongl ong He, Jochen B. Schroeder, Peter Anderekson, Erik Agrillo, Magnus Karlsson; TaiChalmers tekniska hogskola, Sweden. We investigate experimentally and numerically the impact of using different fiber dimensions to spread out the 32-dimensional Voriostat constellations. We find similar performance in experiments and less than 5.4% reach improvements in long-haul transmission simulations by spreading the constellation dimensions over time slots compared to wavelengths.

SC7 – Core & Metro Networks – Posters

We5.40
Distributed Polarization Dependent Loss Monitoring Using Polarization Resolved Pilot Tone, Zhiping Jiang, Xiang Lin, Huawe i Technologies Canada, Canada. We propose and experimentally demonstrate a novel scheme to monitor polarization dependent loss of lightpath segments distributedly using polarization resolved pilot tone technology. Better than 0.1 dB accuracy is achieved.

We5.41
Towards More Accurate and Effective Service Provision in Multiband Transport Networks, Cen Wang, Noboru Yoshikane, Takehiro Tsun tani, KDDI Research Inc., Japan. We propose a novel routing, modulation, and spectrum assignment algorithm for multiband transport networks towards more accurate and effective. The simulation results show significant improvements in lowering the blocking rate and increasing the band utilization.

We5.42
Photonic ally Interconnected Federated Edge-Computing Networks Using Fast Reconfigurable SOA-Based OADMs, Henrique Freire Santana, Rafael Kraemer, Ali Meh feh, Nicola Calabretta, Technische Universiteit Eindhoven, Netherlands; KPN, Netherlands. We propose and demonstrate via BER tests lossless SOA-based optical add/drop multiplexer nodes for low-latency and deterministic photonic ly interconnected federated edge-computing nodes. Experimental results confirm error-free communication for up to 5 nodes with < 3.5 dB power penalty at 25G NRZ-OOK.

We5.43
Comparison of Physical Realizations of Multidimensional Vorion Constellations in Single Mode Fibers, Ali Mirani, Kovendran Vijayaraj, Shen Li, Zonglong He, Jochen B. Schroeder, Peter Anderekson, Erik Agrillo, Magnus Karlsson; TaiChalmers tekniska hogskola, Sweden. We investigate experimentally and numerically the impact of using different fiber dimensions to spread out the 32-dimensional Vorion constellations. We find similar performance in experiments and less than 5.4% reach improvements in long-haul transmission simulations by spreading the constellation dimensions over time slots compared to wavelengths.

SC8 – Access, Indoor & Short-Reach for Data Centres and Mobile Networks – Posters

We5.45
Demonstration of Coverage Extension and Blockage Mitigation by Using THz Relay for Indoor Network, Sang-Rak Moon, Sooyeon Kim, Eon-Sang Kim, Minkyu Sung, Changyu Choi, Hojin Song, Joon Ki Lee, Seung-Hyun Cho; Optical Communication Research Section, Electronics and Telecommunications Research Inst., Korea (the Republic of), Department of Electrical Engineering, Pohang Univ. of Science and Technology, Korea (the Republic of). We propose THz relay for indoor network and investigate its feasibility by experiment. With the THz relay, coverage extension and blockage mitigation are demonstrated with 100 Gb/s 16 QAM signal. Observed non-ideal features were discussed for future improvement.

We5.46
Reclaiming High-Voltage APD Biases From Dropped Optical Data Signals of Multi-Line Interconnects, Bernhard Schrenk, Margareta Vania Stephanie; AIT Austrian Inst. of Technology, Austria. As a method to extend the optical budget of intra-datacenter interconnects, we demonstrate the provision of a >20V APD bias through a shared energy reclamation circuit at the optical data plane. We find a penalty of 0.2 dB with respect to electrically-supplied APDs.

We5.47
Field Trial of 300Gb/s 12-Channel Medium Wave-length-Division Multiplexing in Deployed 5G C-RAN Front-Haul Network, Dong Wang, Dechao Zhang, Gorgyuan Zhao, Jiang Sun, Youyi Lin, Qian Cai, Dawei Ge, Yunbo Li, Liuyan Han, Enbo Zhou, Xiaodong Duan, Han Li, China Mobile Research Inst., China; Huawei Technologies Co Ltd, China; Huawei Technologies Deutschland GmbH, Germany. We report the first real-time field trial of a 300Gb/s 12-channel medium wavelength-division multiplexing (MWD) system in a deployed 5G C-RAN front-haul network, achieving 24-hour error-free transmission of bidirectional eCPRI signals over 10 km SSMF with an optical link budget of over 15 dB.

We5.48
Error-Free 108 Gbps on-Off Keying Link for Optical Interconnect Applications, Osako Ozolins 1, Toms Salgals, Hadrien Louchet, Mahdieh Joharifar, Ali Mefteh 2, Nicola Calabretta 1, Technische Universiteit Eindhoven, Netherlands; KPN, Netherlands. We propose and demonstrate via BER tests lossless SOA-based optical add/drop multiplexer nodes for low-latency and deterministic photonic ly interconnected federated edge-computing nodes. Experimental results confirm error-free communication for up to 5 nodes with < 3.5 dB power penalty at 25G NRZ-OOK.

SC9 – Photonics for RF & Free-Space Optics Applications – Posters

We5.51
SNR-Enhanced Frequency-Occupied 64QAM MM-Wave Signal Generation Using MZM-Based Angle Modulation, Zhenr en Li, Yu Xia, Haiping Song, Mengfan Cheng, Qi Yang, Deming Liu, Ming Tang, Lei Deng, Huazhong Univ. of Science and Technology, China. We propose a novel scheme to generate the signal-to-noise ratio (SNR)-enhanced high-order frequency multiplexation mm-wave signals using angle modulation. An SNR-enhanced 60Gbaud 64QAM signal with a carrier frequency of 28GHz is experimentally generated and transmitted over 25km SMF using a 3.5GHz RF signal and 10GHz MZM.

We5.49
Highly Reliable and Large-Scale Optical Circuit Switch for Intra-Datacentre Networks, Takumi Mitsuya, Takuro Ochiai, Takuma Kudo, Yoshio Mori, Hiroshi Hasegawa, Ken-ichi Sato; Nagoya Univ., Japan; The National Inst. of Advanced Industrial Science and Technology, Japan. We propose a novel optical circuit switch architecture offering high reliability and high capacity. The proposed scheme substantially reduces the annual downtime of the switch with little additional hardware cost. Its transmission performance is experimentally confirmed by constructing part of a 1,536×1,536 optical switch.
We5.52 Demonstration of 1.75 Gbit/s VCSEL-Based Non-Direct-
ed Optical Wireless Communications With OOK and FDE, Malte Hinrichs1,2, Giulio Boniello1, Peter Hellwig1, Dominik Schulz1, Christoph Kottke1, Martin Schubert1, Ronald Bohne1, Wen Xu1, Ronald Freund1,2, Volker Jungnickel1,2, Fraunhofer Heinrich Hertz Inst., Germany; Inst. of Telecommunication Systems, Technische Universität Berlin, Germany; Huawei Technologies Deutschland GmbH, Germany. We evaluate a high power on-off-keying transmitter for non-directed optical wireless communications based on VCSEL-arrays. Error-free transmission after FEC with a net data rate of 1.75 Gbit/s is achieved across a distance of 2.5 m with a coverage area of 3 m².

We5.53 Low-Complexity Multi-Symbol Output Complex-Valued Neural Network for Nonlinear Equalization in 100G Coherent Photonic-Assisted W-Band Fiber-Wireless Integrated Communication, Qijun Bai1, Junlian Jia1, Zhongya Li1, Jianyang Shi1, Nan Chi1,2, Junwen Zhang,2,3, Fudan Univ., China; Peng Cheng Laboratory, China. A low-complexity multi-symbol complex-valued NN nonlinear equalizer is proposed and experimentally demonstrated in coherent photons-assisted millimeter-wave (MMW) communication system. Significant performance improvements are observed for 100Gbps 16-QAM photon-assisted W-band signal after fiber-wireless integrated transmission, while the computational complexity is reduced by up to 78.1%.

We5.54 Spectrum-Efficient Uplink Transmission for Mobile Fronthaul Based on Coherent Detection, Long Huang1, Zhenguo Lu1, Ku Wu1, Jianping Yao1,2, Univ. of Ottawa, Canada; National Research Council Canada, Canada; Polytechnique Montreal, Canada. We propose and demonstrate a novel spectrum-efficient radio-over-fiber (RoF) link based on a dual-drive Mach-Zehnder modulator and coherent detection for uplink transmission of mobile fronthaul. Compared with other RoF links, the proposed RoF link offers a two-fold increase in capacity without additional optical transceivers.

We5.55 Simultaneous Clock and RF Carrier Distribution for Beyond 5G Networks Using Optical Frequency Comb, Zichuan Zhou1,2, Dhecha Nopchinda1, Mu-Chieh Lo1, Izzat Darawal1,2, Zhiyu Liu1,2, Univ. College London, UK. We demonstrate sub-100fs jitter, dispersion-tolerant dissemination of 5GHz-spaced RF tones up to 45GHz using a filtered optical frequency comb, enabling clock and RF carrier synchronised wireless communication systems with 1.4 Gbit/s data rate. The impact of seed laser linewidth on RF phase noise is also studied.

We5.56 Experimental Investigation of Mode Diversity Reception Using an Optical Turbulence Generator and Digital Holography, Vincent Van Vliet1,2, Menno van den Hout1,2, Sjoerd van der Heide1, Chigo Okonkwo1,2, Electrical Engineering, Technische Universität Eindhoven, Netherlands. Mode diversity reception is experimentally investigated using an optical turbulence generator, off-axis digital holography, and digital demultiplexing. The results confirm improved fibre coupling efficiency when receiving the optical field using a multi-mode fibre instead of a single-mode fibre under turbulent conditions, specifically beam wander. The coupling loss is reduced by receiving additional modes.

We5.57 C-band to Multi-Band Network Upgrade by a Multi-Ob-
jective Evolutionary Algorithm-Based Optimization Framework, Ruoxuan Gao1, Yi Teng1, Xiaomin Liu1, Mengyang Chen1, Fangchao Li1, Linlin Yi1, Weisheng Hu1, Qunbi Zhuge1, Shanghai Jiao Tong Univ., China; Ten-
cent, China. We propose a multi-objective evolutionary algorithm-based optimization framework to support the networks upgrading from C-band to multi-band systems by optimizing the amplification module in some sites. Through this framework, a cost-effective upgrade to maintain the network performance can be achieved.

We5.58 Exploring Point-to-Multipoint Coherent Capabilities Across Metro and Core Networks, Ashwin Gumaste1,2, João Pedro1,2, Harald Bock1, Infineera Corporation, USA. We investigate point-to-multipoint coherent capabilities for traffic grooming and provisioning across interdomain metro-edge and metro-core networks. Results highlight benefit of P2MP coherent from a transceiver count perspective.

We5.59 Reinforcement-Learning-Based Multilayer Path Planning Framework That Designs Grooming, Route, Spectrum, and Operational Mode, Takaumi Tanaka1, Katsuki Hi-
gashimori1,2, NTT Network Innovation Laboratories, Japan. We propose a reinforcement-learning-based multilayer path planning framework that designs grooming and optical path parameters. Simulation results show that the proposed method can improve blocking probability by 20 % compared to conventional heuristic methods.

We5.60 Service-Aware Genetic Algorithm for Link Power Control in Multi-Band Optical Transmission Systems, Andre Souza1,2, Nelson Costa1,2, João Pedro1,2, João Pires1,2, Infineera Corp, Portugal; Instituto de Telecomunicações, Universidade de Lisboa Instituto Superior Tecnico, Portugal. We propose a service-aware genetic algorithm for launch power optimization in meshed multi-band optical networks. Results show that adopting different launch power optimization criteria per link enables to selectively increase capacity compared with using a single criterion.

We5.61 Expanding Graph Neural Networks for Ultra-Fast Opti-
cal Core Network Throughput Prediction to Large Node Scales, Robin Matzner1,2, Ruijie Luo1, Georgios Zervas1, Polina Bayvel1, Univ. College London, UK. Using maximum achievable throughput as an objective, message passing neural networks (MPNN) are applied to larger optical networks (25-100 nodes), enabling physical properties-aware large-scale topology optimisation in record time, reducing computation time by 5 orders of magnitude, with close to perfect throughput correlation ($R_{ho}=0.986$).
We present a state-of-the-art approach to improve Quantum Digital Twin (QDT) for application in secure communication and authentication, utilizing the optical photonic platform for quantum communication. The QDT is designed to enhance the performance of parallel addressing and fabricate a waveguide array with custom mode designs and using beam deflectors for rapid addressing. We also demonstrate a system for the calibration of the spectral properties of fibre-coupled devices and report a measurement system for the calibration of the spectral properties of fibre-coupled devices. The system is continuously tunable from 700 nm to 1800 nm. Application fields range from telecommunication to sensors and rapidly growing domains like quantum communication and cryptography.

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We characterize the spectral properties of fibre optics components and devices by using a filter to improve Quantum Key Distribution (QKD) implementations. We show a QDT increasing the key exchange rate under limited resources and environmental events.

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Demo Zone

Wednesday, 21 September, 10:15–15:45, Foyer 3rd Floor

Chair Bert Offrein, IBM Research Zurich, Switzerland

The Demo Zone will provide the opportunity to see live demonstrations and prototypes of research projects, corresponding to all relevant topics of the conference.

The live session will provide a forum for researchers from Industry and Academia to showcase their work with concrete systems, tools and prototypes. The Demo Zone will be open to all conference delegates, providing unique opportunities for potential technological transfer and dissemination of research results.

Tu2.1
Demonstration of Hitless Spectrum Optimization in a Flexgrid Disaggregated System, Dou Liang1, Boyuan Yan2, Jie Wu2, Jing Wu2, Qin Chen2, Rui Lu2, Lei Wang1, Zhao Sun1, Chongxin Xie1; 1Alibaba Cloud, Alibaba Group, China; 2Alibaba Cloud, Alibaba Group, USA. A spectrum optimization method without service interruption is demonstrated in a flexgrid disaggregated system by extending a transponder laser bright tuning range, adapting OpenConfig data models in devices and implementing algorithms in a network management system. The whole system is composed by commercialized devices.

Tu2.2
FDMA Point-to-Multi-Point Fibre Access System for Latency Sensitive Applications, Christian Bluem1,2, Heinrich von Kirchbauer1, Giuseppe Caruso1,2, Pablo Leyva1, Ullrich Wünsche1, Rongfang Huang1, Jinlong Wei1, Ivan N. Cano1, Stefano Calabro1, Giuseppe Talli1; 1Munich Research Centre, Huawei Technologies Duesseldorf GmbH, Germany; 2Politecnico di Torino, Italy; 3Citrobits GmbH, Germany. We present a demo for multiple uplink access system with real-time services. Several terminals transmit and are detected simultaneously through FDMA. The system can allow latency-sensitive and best-effort applications to share the network.

Tu2.3
Experimental Demonstration of Transport Network Slicing with SLA Using the TeraFlowSDN Controller, Luís Gifre Re- noms1, Daniel King1, Adrian Farrel1, Ramon Casellas3, Ricardo Martinez4, Juan-Pedro Fernández-Palacios5, Oscar Gonzalez De Dios1, José Pedroño-Manresa1, Achim Autenrieth1, Raul Muñoz2, Ricardo Vilalta4; 1Old Dog Consulting, UK; 2Telefónica I+D, Spain; 3ADVA Optical Networking SE, Germany; 4Centre Tecnologic de Telecomunicacions de Catalunya, Spain. This demo presents the TeraFlowSDN controller as a solution to provide dedicated transport network slices with SLAs. To this end, the demo details how the interface between an NFV orchestrator and the SDN controller can provide transport network slices using protected disjoint paths.

Tu2.4
Automated Dataset Generation for QoT Estimation in Coherent Optical Communication Systems, Caiyu Santos1, Behnam Shariati2, Robert Emmerich2, Carsten Schmidt-Langhorst1, Colja Schubert1, Johannes Karl Fischer3,4; Fraunhofer-Institut für Nachrichtentechnik Heinrich-Hertz-Institut HHI, Germany. We demonstrate sophisticated laboratory automation and data pipeline capable of generating large, diverse, and high-quality public datasets. The demo covers the full workflow from setup reconfiguration to data monitoring and storage, represented on a digital replica of the setup and updated in near real-time.

Tu2.5
Demonstration of a Real-Time ML Pipeline for Traffic Forecasting in AI-Assisted F5G Optical Access Networks, Mihail Balanici1, Geronimo Bergk1, Pooyan Safari1, Behnam Shariati3, Johannes Karl Fischer3, Ronald Freund2; 1Photonic Networks and Systems, Fraunhofer-Institut für Nachrichtentechnik Heinrich-Hertz-Institut HHI, Germany. We showcase a proof-of-concept demonstration of a ML pipeline for real-time traffic forecasting deployed on a passive optical access network using an XGS-PON compatible telemetry framework. The demonstration reveals the benefits of fine-granular telemetry streaming for QoS monitoring and adaptive capacity adjustment of end-customers.
Short Course: An Introduction to Machine Learning in Optical Networks

Monday, 19 September, 13:30–17:30, Hong Kong

Instructor: Massimo Tornatore, Politecnico di Milano, Italy

Machine learning (ML) has recently attracted a surge of interest in optical networking and communication research due to its pattern recognition and predictive capabilities for various key applications. Large-scale monitoring data are generated every day in optical networks, which makes ML a promising solution for decision making. In this short course, we introduce the fundamental concepts and principles of ML. We survey existing work on various applications at the optical network level, focusing on fault management and quality of transmission estimation. Finally, we carry out a hands-on tutorial for participants showing how to implement a simple application of ML for fault management. We aim to provide a general overview of the key problems, common formulations, existing methodologies and future directions. This course will inspire the audience and facilitate ML research and development in optical networking and communication systems.

The outline is given below:

- Fundamental concepts of ML
- ML Applications:
  - Quality of Transmission
  - Failure detection and identification
  - Overview of other applications
- Hands-on activity

Short Course: Space Division Multiplexing

Tuesday, 20 September, 13:30–17:30, Hong Kong

Instructor: Roland Ryf, Nokia Bell Labs, USA

The transmission capacity required by modern fiber-optic communication systems often significantly exceeds the capacity of a single single-mode fiber, therefore requiring new cost-effective fibers and components to support massive parallel optical paths (space-division multiplexing). Additionally, traditional wavelength-division multiplexing (WDM) based network architectures scale poorly for large numbers of spatial paths and new scalable and cost-effective network architectures are required.

In the first part of short course, we will address various options to implement massive parallel optical fibers links by using various fiber type including commercially available fiber ribbons, multicore fibers and multimode fibers, and discuss the advantages of using parallel optical links regarding transmission capacity and power efficiency.

In the second part we will address optical amplification schemes that support multiple parallel channels like amplifier arrays or cladding pumped fibers amplifiers and related trade-off between the amplification bandwidth, power efficiency, and number of parallel channels, that has recently significantly impacted the design of submarine transmission systems.

The third part of the course will address basic optical switching technologies adapted to support multiple spatial paths and present possible related ultra-high capacity network architectures and address the implications on scalability, network management, and integration with existing WDM systems.

Additionally, the short course will also address more forward-looking SDM technologies like mode-division multiplexing in multimode and coupled-core fibers based on coherent multiple-input-multiple-output (MIMO) digital signal processing, quasi-single-mode transmission, mode-group-division multiplexing, and general transmission over channels with crosstalk.

Short Course: Forward Error Correction

Tuesday, 20 September, 13:30–17:30, Guangzhou

Instructor: Laurent Schmalen, KIT, Germany

This course is intended for engineers and students who would like to get a background in the basic concepts in forward error correction techniques but would like to take a deeper outlook into the modern concepts and technologies that are employed in today’s high-speed optical communication systems. The course is intended to give participants insights on the selection of FEC schemes for different applications and the understanding of LDPC-based FEC schemes, which form one of the most popular coding schemes in optical communications these days.

Some of the topics covered in the course are:

1. Recapitulation of basic concepts of forward error correction (FEC)
2. Hard-decision decoding versus soft-decision decoding
   a. Basic concepts, potential gains and possible limitations
   b. Guidelines for decoding method selection depending on application
3. Applying forward error correction in optical transmission experiments
   a. Performance characterization using information theoretic methods
   b. Performance evaluation using real decoders
4. In-depth treatment of modern FEC schemes
   a. Product codes and staircase codes for hard-decision decoding
   b. Concatenated coding schemes
   c. LDPC codes for soft- and hard-decision decoding
     i. Common designs of parity-check matrices, e.g., Quasi-Cyclic (QC) codes
     ii. Decoding LDPC codes – algorithms for soft-decision and hard-decision decoding
     iii. Decoding LDPC codes – hardware implementation aspects
     iv. Simulation of LDPC codes on FPGAs for error floor analysis
Short Course: Modulation Formats and Receiver Concepts for Optical Transmission Systems
Wednesday, 21 September, 08:30–12:30, Hong Kong

Instructors
Peter Winzer, Nubis Communications, USA
Xi (Vivian) Chen, Nokia Bell Labs, USA

The ever-increasing traffic demands in carrier networks, driven by emerging data-centric services and applications, have led to intense research and development in the area of high-capacity (> 100 Tbit/s), high-speed (> 1 Tb/s per wavelength) optical transport networks. In order to enable such high capacities and speeds over appreciable transmission distances (> 1,000 km), spectrally efficient yet impairment-tolerant transmission technologies have moved into the focus of optical communications research and have led to considerable innovation in modulation and detection strategies. This course gives an overview of modulation formats and multiplexing techniques for optical networking applications, both from a conceptually fundamental and from a state-of-the-art technological point of view. The discussed modulation formats include intensity modulation, phase modulation, and quadrature amplitude modulation; multiplexing techniques include wavelength division multiplexing (WDM), polarization division multiplexing (PDM), subcarrier multiplexing, discrete multi-tone (DMT) and orthogonal frequency division multiplexing (OFDM), and space division multiplexing (SDM). The course covers basic optical receiver design and optimization principles, both for direct-detection and digital coherent (intradayne) receivers, including the underlying digital electronic signal processing (DSP) at both the receiver and the transmitter, as well as some fundamentals of error correcting coding techniques from a systems perspective. Finally, the course highlights the interplay of modulation format, receiver design, and the wide variety of transmission impairments found in optically routed long-haul networks and points to latest research trends in optical modulation and multiplexing.

Short Course: Radio-over-Fiber Technologies
Wednesday, 21 September, 13:30–17:30, Hong Kong

Instructor
Dalma Novak, Octane Wireless, USA

The use of fiber-optic links for transporting radio signals in wireless networks is a well-established technology and the convergence of optical and wireless networks continues to evolve. Fiber-optic remoting of radio signals is used in a diversity of wireless networks, including indoor/in-building distributed antenna systems and outdoor cellular networks. The benefits of creating end-to-end integrated network solutions that can provide reliable service for both fixed and mobile users, have become well documented. Today the capabilities of wireless networks are progressing more rapidly than ever. The proliferation of connected high capacity smart devices as well as the increase in the number of broadband multi-media services available to the consumer, has led to an escalating demand for wireless access to high-speed data communications. The next generation 5G/6G network promises to deliver unprecedented data rates to the mobile user and the millimeter-wave frequency region is being actively pursued for the provision of these services. The realization of integrated optical/wireless networks that can reliably and cost-effectively support current and future capacity demands, traffic growth rates, new services, as well as multiple wireless standards, is presenting new challenges and opportunities for emerging radio-over-fiber technologies. This short course will provide participants with a fundamental understanding of technologies that enable the fiber-optic distribution of analog and digital radio signals and the variety of systems in which such links are being implemented. These applications include indoor distributed antenna systems and emerging wireless networks such as 5G, capable of providing users with very high bandwidth services.
Special Events

Technorama Exhibition
Sunday, 18 September – Thursday, 22 September, Foyer 2nd Floor
Organiser: Swiss Science Center Technorama

Technorama is one of the largest science centres in the world. Initiated by the ECOC outreach event, Technorama provides ten hands-on experiments based on light for everybody to try and get stunned. So here’s our tip: trust your instincts! The rest falls into place if you let your curiosity, joy in experimenting and play take the lead.

Light & Sight – Nothing determines our perception of the world more than light. Although not actually tangible, this mobile exhibition offers a real hands-on experience. Here, visitors weave with light and throw Coloured Shadows where one would actually expect black ones. Polarised Light quite literally casts our environment in another light. Or discover plasma, the stuff of which stars are made. Exciting and aesthetic experiments with this fourth state of matter are gathered here. Dompt serpentine strands of electrons with your bare hands – at the Plasma Ball in the entrance area!

IONS+ Supercharge Your Conference Experience
Sunday, 18 September, 09:00–17:45, Kairo
Organisers: Helena Weigand, ETH Zurich, Switzerland
Hande Ibili, ETH Zurich, Switzerland
Killian Keller, ETH Zurich, Switzerland
Yannik Horst, ETH Zurich, Switzerland
Ayhan Furkan, EPFL, Switzerland

A program designed for students and early-career professionals with a focus on maximizing the ECOC experience and networking. Highlights are:
- What Can I Do After My PhD? Inputs from Successful People
- Pimp your Presentation! – Workshop

Training Course on Integrated Photonic Technologies
Tuesday, 20 September, 09:00–12:30, Delhi
Organisers: Hugo Thienpont, Vrije Universiteit Brussel, Belgium
Roel Baets, ePIXfab, Belgium
Kevin Williams, JePPiX, Netherlands
Peter O’Brien, Tyndall, Ireland
Jurgen Van Erps, Vrije Universiteit Brussel, Belgium

Topics covered in the PhotonHub training course are: PhotonHub Europe Overview, Si & SiN Photonic Devices & MPW Services, InP Photonic Devices & MPW Services, Integrated Photonic Packaging Technologies, Micro Optics & Interconnect Technologies for Integrated Photonics

Outreach: TecDay for High School Students
Tuesday, 20 September, 10:00–17:00, Start in Boston
Organisers: SATW – Swiss Academy of Engineering Sciences
ECOC 2022 – Special Technical Programme Chairs

Dive in with your school class into the world of optical communication and breathe international conference air. SATW and ECOC 2022 invite classes of Swiss high schools to a stunning programme with workshops, experiments, scientific talks and an exhibition.

Special Workshop: Diversity in Action: Creating a Diverse and Inclusive Workplace, a Place for All to Belong
Tuesday, 20 September, 10:45–12:30, Kairo
Organisers: Selina Farwell, Lumentum, UK
Fatima Gunning, Tyndall National Institute, Ireland
Lauren Mecum-Smith, IEEE Photonics Society, USA
Marcia Lesky, Optica, USA
Allison Romanyszyn, SPIE, USA

Diversity of thought drives new ideas and innovation. The workshop kicks off with a presentation reminding us of published data linking a diverse workforce and innovation value. Organizations which embrace diversity and inclusion have a strategic advantage because it delivers a broad range of business benefits. These include improved business performance and financial success, with employees that are highly engaged, more happy, healthy, and productive, improved retention of staff and generation of more and better ideas. If we want to have the strategic advantage of diversity, what inclusive behaviors should we adopt?

Are role models important, should we have mentors? What should interview panels look like and how to ensure that diverse people are heard? How can we have equal and fair networking opportunities and team building? What’s the role of leadership teams?

Let’s hear from organizations who are on a journey to realize the broad business benefits that the research predicts. Three leaders will openly share the problems they faced in their business and what compelled them to act. We will learn what initiatives truly created a diverse and inclusive workplace and what completely missed the mark. The objective is to take away the top three lessons each organization has learnt.

In this workshop, we will discuss best practice instituted policies and programs which made a difference to inclusion, employee engagement, a sense of workplace belonging and career success. The workshop includes a motivational talk followed by position talks from industry and academia followed by a panel discussion.

This workshop is designed for supervisors, managers, team leaders and anyone who is interested in promoting diversity.
13th European Photonic Integration Forum at ECOC 2022
Tuesday, 20 September, 16:30–18:30, Delhi

Organisers  JePPIX
JePPIX and ePIXfab have joined forces again to organize the 13th edition of the European Photonic Integration Forum (EPIF). The purpose of this year’s EPIF is to sum-up the PIC-year since last ECOC in terms of PIC developments and the people behind these key developments. We will bring an impressive PIC start-up story, a corporates PIC-vision, and exciting stories of latest PIC-developments by JePPIX partners and ePIXfab members.

The highlight of the program will be two 30-minute interview sessions from and with high-profile speakers from the PIC industry. A Q&A session with the audience will be included here. JePPIX partners and ePIXfab members will also introduce recent developments (new products, new services, other announcements) through a series of 1-minute videos. The EPIF will conclude with a networking reception, during which extra visibility will be given to our sponsors.

Lab Automation Hackathon
Tuesday, 20 September, 17:30–19:00, Rio

Organisers  Jochen Schroeder, Chalmers University of Technology, Sweden
Marco Eppenberger, ETH Zurich, Switzerland
Nicolas Fontaine, Nokia Bell Labs, USA
Binbin Guan, Microsoft, USA
Roland Ryf, Nokia Bell Labs, USA

Come network with students and researchers and discuss lab automation and programming in a relaxed atmosphere with some food and drinks.

Lab work is most efficient when you do your measurements, and data acquisition in an automated way, especially so when running long experiments of hours or days. Automated data acquisition makes experiments reproducible, avoids the human errors and allows experimentalists to concentrate on the fun parts of working in the lab.

Open source software in easy-to-learn languages such as Python provides just as much, or even more features/interoperability for lab automation than alternative commercial software. On top of that, the many packages written by the large community allow you to quick and easily write graphical user interfaces, create numerical simulations or design your components.

The hackathon format will consist of multiple interactive demos, discussion tables, and an informal Q&A. Researchers, students, and industry professionals will show you how to get your lab experiment running, your design space explored, or your machines to learn. 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.

EPIC Members Run at ECOC
Wednesday, 21 September, 06:30–08:40, Start in front of Sorell Hotel Merian

Organisers  EPIC – European Photonics Industry Consortium
Swissphotonics

Stay active with EPIC during our common time at ECOC exhibition in Basel. To stimulate networking, build new relations and strengthen friendships, EPIC is organizing a morning run activity, followed by a networking breakfast. All EPIC members are welcome to join (1 person per company policy).

Rump Session: Analysis and Real Opportunities from the Hyped Big Trends in Photonics
Wednesday, 21 September, 17:30–19:00, Samarkand + Osaka

Organiser  Jose Pozo, CTO, Optica, USA

You are invited to join this year’s ECOC’s rump session. In a relaxed atmosphere and a very interactive session by all the attendees, the scope of the meeting is to discuss how current trends in Photonics can help us shape our preferred future. From Free Space Communication to co-packaged optics, from next-generation transceivers to Quantum Computing, our industry is both benefited and been challenged by the impact of technology trends.

Drinks and snacks will be provided to create a relaxing atmosphere.

Workshop on Photonic Startups and Entrepreneurship
Tuesday, 20 September, 17:30–19:00, Kairo

Organiser  Erik Pennings, 7 Pennies Consulting, USA

The photonics industry continues to be a dynamic market in which innovation takes place at a breathtaking pace. And much of this innovation is driven by startup companies.

While many people like to start a company and many admire the startups that made it big, the process of starting company can be challenging.

The aim of this workshop is to provide practical guidelines and do’s and don’ts by featuring a number of seasoned entrepreneurs who tell their story. The focus of the presentations is to share key insights and lessons learned that are useful for any entrepreneur wanting to start a company or develop a new business. The workshop concludes with a panel session with ample room for questions and answers.

This startup workshop will be the 9th edition and it has been held in conjunction with either ECOC or OFC. Handouts of previous startup workshops including all presentations can be found on https://www.7pennies.com/news-events/startup-workshop/.

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Social Events

Get-together Reception
Sunday, 18 September, 19:00–21:00
Congress Center Basel, Foyer 2nd Floor

During the Get-together reception on Sunday, you will get the opportunity to meet and socialise with colleagues that are attending the conference. We hope to meet all of you enjoying a memorable get-together moment.

Invited: All conference delegates
Fee: Included in the conference fee

Welcome Reception
Monday, 19 September, 19:30–23:00
Markthalle Basel, Steinentorberg 20, 4051 Basel

The ECOC 2022 Welcome Reception will take place in Basel’s Markthalle (Market Hall), which was built in 1929 and today is used as a food market with food stalls from all over the world. Join this unique experience and enjoy national and international food in a relaxed environment perfect to connect and exchange with other conference attendees and exhibitors.

Invited: All conference delegates and exhibitors
Fee: Included in the conference fee / CHF 40 for exhibitors

Gala Dinner
Tuesday, 20 September, 19:30–23:00
MS Rhystärn, Basel Schiffände, 4051 Basel

The ECOC 2022 Gala Dinner will take place on the boat MS Rhystärn cruising the river Rhine. The cruise will offer scenic views of Basel and area in stunning evening light – a breathtaking experience you do not want to miss.

Invited: Conference delegates with tickets. A limited number of tickets can be purchased at registration desk.
Fee: CHF 100

VIP Dinner
Wednesday, 21 September, 19:30–23:00
Restaurant Safran Zunft, Gerbergasse 11, 4001 Basel

The ECOC 2022 VIP Dinner will take place in the guild hall of the Safran Zunft (Saffron Guild) of the city of Basel. Experience a stunning historic guild hall with authentic ambience and traditional charm. Enjoy traditional food with a modern touch in a central location near the historic market square.

Invited: Event to honour the volunteers who have committed to organising ECOC 2022.
Fee: By invitation only
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48th European Conference on Optical Communication • 18–22 September 2022
General Information

Conference Venue & Hours
Congress Center Basel
Messeplatz 21
4058 Basel
Switzerland
Sunday, 18 September, 09:00–19:00
Monday, 19 September, 09:00–18:00
Tuesday, 20 September, 08:30–19:00
Wednesday, 21 September, 08:30–19:00
Thursday, 22 September, 08:30–16:00

Exhibition Venue & Hours
Messe Basel
Messeplatz 10
4005 Basel
Switzerland
Monday, 19 September, 09:30–17:00
Tuesday, 20 September, 09:30–17:00
Wednesday, 21 September, 09:30–16:00

Registration
(Entrance ECOC Exhibition Hall 1)
Saturday, 17 September, 15:00–17:00
Sunday, 18 September, 08:00–19:00
Monday, 19 September, 08:00–18:00
Tuesday, 20 September, 08:00–18:00
Wednesday, 21 September, 08:00–17:30
Thursday, 22 September, 08:00–13:30

Cloakroom
(Entrance ECOC Exhibition Hall 1–Upper Level)
Sunday, 18 September, 08:00–21:00
Monday, 19 September, 08:00–19:00
Tuesday, 20 September, 08:00–18:00
Wednesday, 21 September, 08:00–18:00
Thursday, 22 September, 08:00–16:30
Fee: CHF 2 / EUR 2 per item (cash only)

Speaker Room
(Room Nairobi)
Sunday, 18 September, 08:00–18:00
Monday, 19 September, 08:00–18:00
Tuesday, 20 September, 08:00–18:00
Wednesday, 21 September, 08:00–18:00
Thursday, 22 September, 08:00–15:00

Coffee Breaks
(Free for Conference Delegates)
Sunday, 18 September, 10:30–11:00, 15:30–16:00
Congress Center, Foyer 2nd Floor
Monday, 19 September, 10:20–11:00, 15:15–15:45
ECOC Exhibition Hall 1
Tuesday, 20 September, 10:15–10:45, 15:15–15:45
ECOC Exhibition Hall 1
Wednesday, 21 September, 10:15–10:45, 15:15–15:45
ECOC Exhibition Hall 1
Thursday, 22 September, 10:15–10:45
Congress Center, Foyer 2nd Floor

Lunch
Lunch is not included in the conference registration fee. You will find various catering vendors in the Congress Center, the ECOC Exhibition and local restaurants surrounding the conference venue.

Name Badges
Delegate badges must be worn at all times to gain access to the conference sessions, exhibition and social events. Please note that we cannot replace lost badges.

Oral, Poster and Demo Presentations
All information and instructions for oral, poster and demo presentation can be found on the ECOC webpage.

Postdeadline Papers (PDPs)
PDPs will be announced on Monday, 19 September on the news board and the ECOC webpage.

App
The conference is embedded in the app Optica Events, which is available for Android and iOS devices. The app contains useful information, personalised schedule, access to full papers and much more.

Wi-Fi (Free)
SSID: ECOC_2022
Password: ECOC_2022

Currency
The currency in Switzerland is the Swiss Franc. There are various ATMs outside the exhibition hall.

First Aid
There are paramedics at the venue. In case of medical need, come to the conference registration desk, or talk to any of the student assistants on site. In case of an emergency, call the emergency number 112.

Lost-and-Found
Lost-and-Found property will be collected at the conference registration desk.

Press Room
The press room is located at the ECOC exhibition in Hall 1 and open during exhibition times. Only press representatives correctly identified will be allowed to use this room.

Insurance
The organisers cannot be held responsible for accidents to participants or for damage to or loss of their personal property, howsoever caused.

Contact
The conference secretariat is located in room Miami and can be reached by email to info@ecoc.info.
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