Programme Book

48th European Conference on Optical Communication

18 – 22 September 2022

Basel, Switzerland

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ecoc 2023 GLASGOW

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.

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Programme Overview

	Samarkand+Osaka	Singapore	Sydney	Rio	Boston	Shanghai	Kairo	Delhi	Foyers / San Francisco
Sunday, 18 September									
08:00 - 19:00	**Registration**, *Entrance Hall 1*								
09:00 - 10:30	**WS02 • Role of Optical Network for Split Computing Between Edge and Cloud in Support of Ultra Low Latency Services**	**WS04 • Adaptive Everything! Do Optical Networks Really Need More Flexibility?**	**WS06 • F5G and Evolution Towards F6G**	**WS08 • Life Above 100-GHz: Terahertz Device and System Challenges and Opportunities**	**WS10 • (On-chip) Frequency Combs from NIR to THz**	**WS12 • Heterogeneous Photonic Integrated Circuits**	**IONS+ Supercharge Your Conference Experience**	**WS14 • Linear Optics – A Solution for Efficient AI, Hard Problems Solving, Quantum and Microwave Technologies?**	
10:30 - 11:00	**Coffee Break**, *Foyer 2nd Floor*								
11:00 - 12:30	**WS02 • Role of Optical Network for Split Computing Between Edge and Cloud in Support of Ultra Low Latency Services**	**WS04 • Adaptive Everything! Do Optical Networks Really Need More Flexibility?**	**WS06 • F5G and Evolution Towards F6G**	**WS08 • Life Above 100-GHz: Terahertz Device and System Challenges and Opportunities**	**WS10 • (On-chip) Frequency Combs from NIR to THz**	**WS12 • Heterogeneous Photonic Integrated Circuits**	**IONS+ Supercharge Your Conference Experience**	**WS14 • Linear Optics – A Solution for Efficient AI, Hard Problems Solving, Quantum and Microwave Technologies?**	
12:30 - 14:00	**Lunch Break**								
14:00 - 15:30	**WS03 • The Path Towards Terabit/s PONs: Enabling Multi Gbit/s Data Rate Services**	**WS05 • Are Multi-band Optical Networks Simple Extensions of Traditional C-band Networks?**	**WS07 • Which Technologies Will Be Needed for 6G?**	**WS09 • Moving from Optical Components in RAN to Optical Components for RAN**	**WS11 • Quantum Communication – Hype or Ripe? From QKD Networks to a Global Quantum Internet**	**WS13 • Photonic and Electronic Co-integration Solutions**	**IONS+ Supercharge Your Conference Experience**	**WS15 • Emerging Fiber Technologies for Transmission and Amplification**	**WS01 • Optical Networks – Will They Destroy the Planet or Save Humanity?** *San Francisco*
15:30 - 16:00	**Coffee Break**, *Foyer 2nd Floor*								
16:00 - 17:30	**WS03 • The Path Towards Terabit/s PONs: Enabling Multi Gbit/s Data Rate Services**	**WS05 • Are Multi-band Optical Networks Simple Extensions of Traditional C-band Networks?**	**WS07 • Which Technologies Will Be Needed for 6G?**	**WS09 • Moving from Optical Components in RAN to Optical Components for RAN**	**WS11 • Quantum Communication – Hype or Ripe? From QKD Networks to a Global Quantum Internet**	**WS13 • Photonic and Electronic Co-integration Solutions**	**IONS+ Supercharge Your Conference Experience**	**WS15 • Emerging Fiber Technologies for Transmission and Amplification**	**WS01 • Optical Networks – Will They Destroy the Planet or Save Humanity?** *San Francisco*
18:00 - 19:00	**Nobel Laureate Lecture**, *San Francisco*								
19:00 - 21:00	**Get Together Reception**, *Foyer 2nd Floor*								
Monday, 19 September									
08:00 - 18:00	**Registration**, *Entrance Hall 1*								
09:00 - 10:20	**Mo1 • Opening Remarks and Joint Plenary Session**, *San Francisco*								
10:20 - 11:00	**Coffee Break**, *Exhibition Hall 1*								
11:00 - 12:00	**Mo2 • Joint Plenary Session**, *San Francisco*								
12:00 - 13:30	**Lunch Break**								
13:30 - 15:15	**Mo3A • ML Driven Optical Networks**	**Mo3B • Low Margin Optical Networks**	**Mo3C • Optical Access Networks for Mobile Com.**	**Mo3D • Modulation and Coding**	**Mo3E • Swiss Symposium - Light and Time**	**Mo3F • PIC Components**	**Mo3G • Multidisciplinary Photonics**	**Mo3H • Symposium on 50 Years of Fibre Optics**	
15:15 - 15:45	**Coffee Break**, *Exhibition Hall 1*								
15:45 - 17:30	**Mo4A • Sensing with Optical Networks**	**Mo4B • Edge Cloud and Low Latency**	**Mo4C • Current Challenges for PON**	**Mo4D • SDM and Submarine**	**Mo4E • Swiss Symposium - Light and Time**	**Mo4F • (Bi)CMOS Optoelectronics**	**Mo4G • Novel Photonic Platforms and Sources I**	**Mo4H • Symposium on 50 Years of Fibre Optics**	
17:30 - 18:30	**Mo5A • Poster Pitch Session I**	**Mo5B • Poster Pitch Session II**	**Mo5C • Poster Pitch Session III**						
19:30 - 23:00	**Welcome Reception**, *Markthalle Basel*								
Tuesday, 20 September									
08:00 - 18:00	**Registration**, *Entrance Hall 1*								
08:30 - 10:15	**Tu1A • High-Baud Rate Optical Communication**	**Tu1B • New Trends in Optical Networks**	**Tu1C • Quantum and Future Access Technologies**	**Tu1D • Nonlinear Transmission Modeling**	**Tu1E • Mid-IR Devices and Circuits**	**Tu1F • Co-Packaging and Large Photoic Circuits**	**Tu1G • Metadevices and High-speed Photonics**	**Training on Integrated Photonic Technologies**	
10:15 - 10:45	**Coffee Break**, *Exhibition Hall 1*								**Tu2 • Demo Zone** Foyer 3rd Floor
10:45 - 12:30	**Exhibition Only**						**Special Workshop: Diversity in Action**	**Training on Integrated Photonic Technologies**	
12:30 - 13:30	**Lunch Break**							**Tu3H • Symposium: IEEE International Network Generations Optics Roadmap, 1st Edition**	
13:30 - 15:15	**Tu3A • Fiber for High Capacity Transmission**	**Tu3B • Security**	**Tu3C • High Performance Computer Networks & High Throughput Transceivers**	**Tu3D • Sensing and Nonlinearity Tolerant Schemes**	**Tu3E • Lasers for Silicon Photonics and Sensing**	**Tu3F • Satellite based Optical Freespace Communication I**	**Tu3G • Novel Photonic Platforms and Sources II**		
15:15 - 15:45	**Coffee Break**, *Exhibition Hall 1*								
15:45 - 17:30	**Tu4A • Fiber Sensing and Characterization**	**Tu4B • Symposium: Recent Advances in Submarine Systems**	**Tu4C • High-Speed PON Technologies**	**Tu4D • Free-Space and Quantum Communication**	**Tu4E • Advanced Modulators**	**Tu4F • FSO Communication**	**Tu4G • Photonic Neural Networks**	**13th European Photonic Integration Forum**	
17:30 - 19:00				**Lab Automation Hackathon**			**Workshop on Photonic Startups & Entrepreneurship**		**Tu5 • Poster Session I** Foyer 2nd Floor
19:30 - 23:00	**Gala Dinner**, *MS Rhystärn, Schifflände Basel*								

	Samarkand+Osaka	Singapore	Sydney	Rio	Boston	Shanghai	Kairo	Delhi	Foyers / San Francisco
Wednesday, 21 September									
08:00 - 17:30					**Registration**, *Entrance Hall 1*				
08:30 - 10:15	We1A • Ultrawideband Optical Systems	We1B • Network Planning and Cost Efficiency	We1C • Digital Optical Fiber Nonlinearity Mitigation	We1D • Subsea Communications	We1E • Heterogeneous Integration	We1F • MW Photonics and Lidar	We1G • Symposium: Nonlinear Optics in χ(2) & χ(3) Integrated Photonics	We1H • 8th International Symposium for Optical Interconnect in DCs	
10:15 - 10:45					**Coffee Break**, *Exhibition Hall 1*				
10:45 - 12:30	We2A • DCI and Metro Transmission Systems	We2B • Control Plane and Automation	We2C • Deep Learning for Optical Fiber Communications	We2D • IM/DD & Short-Reach Communications	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 DCs	
12:30 - 13:30					**Lunch Break**				
13:30 - 15:15	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 It Revolutionize the Internet?	We3H • 8th International Symposium for Optical Interconnect in DCs	
15:15 - 15:45					**Coffee Break**, *Exhibition Hall 1*				
15:45 - 17:30	We4A • Scattering and Nonlinear Effects in Fibers	We4B • Optical Networks for Sensing and Sensing for Optical Networks	We4C • Digital Signal Processing for Novel Applications	We4D • Wide-band Technologies and Transmission	We4E • Silicon Photonics	We4F • Satellite Based Optical Freespace Communication II	We4G • Symposium: Photonic-Electronic Memristors for Neuromorphic Applications	We4H • 8th International Symposium for Optical Interconnect in DCs	
17:30 - 19:00	Rump Session								We5 • Poster Session II Foyer 2nd Floor
Thursday, 22 September									
08:00 - 13:30					**Registration**, *Entrance Hall 1*				
08:30 - 10:15	Th1A • Novel Fiber Fabrication Methods	Th1B • Symposium: Free Space Optical Communication for Terrestrial & Space Applications	Th1C • Novel Equalization Techniques	Th1D • SDM Transmission and Monitoring Systems	Th1E • High-speed Transmitter Devices	Th1F • Novel PICs and Applications	Th1G • Quantum Communication	Th1H • Symposium: Prospects for the Usage of Millimeter Wave Bands	
10:15 - 10:45					**Coffee Break**, *Foyer 2nd Floor*				
10:45 - 12:30	Th2A • Single Core and Multicore Fiber Amplifiers	Th2B • Symposium: Free Space Optical Communication for Terrestrial & Space Applications	Th2C • High Baud Rate Transmission	Th2D • Intra-data Centre Networks	Th2E • Photodiodes and Photodetectors	Th2F • Non-Linear Devices and Packaging	Th2G • Quantum Photonics	Th2H • Symposium: Hybrid Integration of III-V Devices with Silicon-based Waveguides	
12:30 - 13:30					**Lunch Break**				
13:30 - 15:15	Th3A • Postdeadline Session III	Th3B • Postdeadline Session I	Th3C • Postdeadline Session II	Th3D • Postdeadline Session IV					
15:15 - 15:45	**Closing Ceremony**, *Singapore*								

Colour Legend & Technical Sub-committees

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

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 fiber (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 Queloz 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 an 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:

- Symposium on the history of fiber optics with the pioneers and inventors
- Public workshop on green optical networks
- Workshops on fixed and mobile 5G & 6G
- Workshops on future optical network technologies
- 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!

Juerg Leuthold
ETH Zurich
General Co-Chair

Christoph Harder
Swissphotonics
General Co-Chair

Bert Offrein
IBM Research Zurich
Regular Technical Programme Co-Chair

Hans Limberger
EPFL
Regular Technical Programme Co-Chair

Rachel Grange
ETH Zurich
Special Technical Programme Co-Chair

Niels Quack
University of Sydney
Special Technical Programme Co-Chair

Christian Bosshard
Swissphotonics
Local Programme Chair

Ueli Koch
ETH Zurich
General Manager

Committees

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 Lerminiaux, Chimie ParisTech – PSL, France
Juerg 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

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Jintong Lin, Beijing University of Posts and Telecommunications, China
Toshio Morioka, 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, Prysmian, France
Christian-Alexander Bunge, Leipzig University of Applied Sciences, Germany
Tommy Geisler, OFS, Denmark
Ian McClean, II-VI, UK
Kazunori Mukasa, Furukawa Electric Co. Ltd., Japan
Rogerio Nougueira, Instituto De Telecomunicacoes, Portugal
Luca Palmieri, Universita di Padova, Italy
Francesco Poletti, University of Southhampton, UK
Luc Thévenaz, EPFL, Switzerland
Seong Woo Yoo, Nanyang Technological University, Singapore
Marc Wuilpart, University of Mons, Belgium

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 Unisersity, Korea
Hélène Debregeas, 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

SC3 – Photonic Integrated Circuits, Assemblies & Packaging

Chair: Dan Kuchta, IBM Research, USA

Selina Farwell, 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 Okonkwo, Eindhoven University of Technology, Netherlands

Elie Awwad, IMT Paristech, France
Xi (Vivien) Chen, Nokia Bell Labs, USA
Francesco Da Ros, Technical University of Denmark, Denmark
Chris Fludger, Infinera Corporation, Germany
Domanic Lavery, Infinera, UK
Emmanuel Le Taillandier de Gabory, NEC, Japan
Chao Lu, Hong Kong Polytechnic University, Hong Kong
Sebastian Randel, Karlsruhe Institute of Technology, Germany
Christoph Studer, ETH Zurich, Switzerland
Sander Wahls, Delft University, Netherlands
Fatih Yaman, NEC Labs, USA

SC5 – Theory of Optical Communications

Chair: René Essiambre, Nokia Bell Labs, USA

Alex Alvarado, Eindhoven University of Technology, Netherlands
Christian Antonelli, Universita dell'Aquila, Italy
Junho Cho, Nokia Bell Labs, USA
Francisco Diaz 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
Mariia 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 Politecnica de Valencia, Spain
Alexii Pilipetskii, Subcom, USA
Jeremie Renaudier, Nokia Bell Labs, France
Jochen Schröder, Chalmers University, Sweden
Paolo Serena, Parma University, Italy
Jaroslaw 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 Baeuerle, 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 Peloponnese, 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
Paulo Monteiro, University of Aveiro, Portugal
Thas Nirmalathas, University of Melbourne, Australia
Stephan Pachnicke, Christian-Albrecht University of Kiel, Germany
Paola Parolari, Politecnico di Milano, Italy
Nikos Pleros, Aristotle University of Thessaloniki, Greece
Fabienne Saliou, Orange, France
Michela Svaluto Moreolo, CTTC, Spain
Karl Tran, Genexis, Netherlands
Tomoaki 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
Maite Brandt-Pearce, University of Virginia, USA
Zizheng Cao, Eindhoven University of Technology, Netherlands
Guillermo 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 Ossieur, imec - Ghent University, Belgium
Leif Katsuo Oxenløwe, Technical University of Denmark, Denmark
Xiaoke Yi, University of Sydney, Australia

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 Issenhuth, Huawei, USA
Raul Muñoz, CTTC, Spain
Yvan Pointurier, Huawei, France
Emilio Riccardi, Telecom Italia, Italy
Marco Ruffini, Trinity College Dublin, Ireland
Gangxiang Shen, University of Soochow, China
Jesse Simsarian, Nokia Bell Labs, USA
Anna Tzanakaki, University of Athens, Greece
Raimena Veisllari, Ericsson, Norway

CLEO®/Europe Focus Meeting

Quantum Photonics

Co-Chair: Patrick Maletinsiky, 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 Emboras, ETH Zurich, Switzerland

Emerging Photonic Devices, Technologies & Applications

Co-Chair: Giacomo Scalari (Co-Chair), ETH Zurich, Switzerland

Ileana-Cristina Benea-Chelmus, EPFL, Switzerland
Stephane Kena-Cohen, École Polytechnique de Montréal, Canada
Marco Peccianti, Sussex University, UK

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 photonic 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

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 Collegwwe 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 Levorato, 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
Ramon 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 Schares , 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 to 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
Domaniç Lavery, Infinera, Canada
Sergejs 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
- F5G 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, Prysmian, 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 Elmirghani, 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 Open 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 Chanclou, 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 Potì, 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 panelists 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 Pasquazi, University of Sussex, UK

Broadband Mid-Infrared Supercontinuum Generation on a CMOS-based Chip
Christian Grillet, 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

Microresonator 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, ADVA 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
Ségolène 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
Martijn 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

Heterogenous 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.X μm GaSb/Si Laser Spectrometers
Augustinas Vizbaras, BROLIS, 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

Integrated CMOS-Compatible Femtosecond Lasers for Photonic ADCs
Franz Kärtner, Center for Free-Electron Laser Science & University of Hamburg, Germany

Reservoir Computing with Optical Weights
Stijn Sackesyn, UGent-imec, Belgium

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 Optical circuits 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, Salience 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 Mourgias-Alexandris, Microsoft 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

165 Coupled Core Fibers for MM and SDM Transmissions
Ming-Jun Li, Corning, 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 Francesco 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

Tu4B • Recent Advances in Submarine Systems

Tuesday, 20 September, 15:45–19:00, *Singapore*

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 Fevrier, Meta, USA

Open Innovation in Japan for Next Generation Submarine Networks
Yoshihisa 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

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

Wednesday, 21 September, 08:30–10:15, *Kairo*

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 focusses 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

Topics & Speakers

Lithium Niobate Integrated Photonics, from Highly Nonlinear to a Few Photons
Victor Brasch, 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

We2G • Diamond Nanophotonic Quantum Networks

Wednesday, 21 September, 10:45–12:30, *Kairo*

Quantum processors promise to deliver enormous computational power for solving problems which lie beyond the capabilities of classical machines. There are many hardware platforms on which quantum computing can be developed, and it is not yet clear which technological approach will prove most successful. Photonic technologies face challenges because of the need to generate and transform the required quantum states on demand.

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 focusses 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, CTTC, 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 $BaTiO_3$ Ferroelectric Multilevel 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 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.

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, 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, Infinera, 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 SpaceBACN 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
Pavlos 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
Juerg Leuthold & David Moor, ETH Zurich, Switzerland

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

Thursday, 22 September, 08:30–12:30, *Singapore*

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

Topics & Speakers

Seamless Connectivity in and to Space via Optical Links
Harald Mathias Hauschildt & Josep Maria Perdigues Armengol, ESA, Netherlands

Connectivity for Deep Space Missions and Exploration via Optical Communication
Klaus Jürgen Schulz & Clemens Heese, ESOC, Germany

Optical Communication for Space Application – Data Relay
Gregory Mark, TESAT SpaceCom, Germany

Optical Communication for Space – Space-to-Ground
Cyrille Laborde & Klaus Buchheim, Thales Alenia Space, France & Switzerland

Next-generation Wireless: Connecting the World with Taara Wireless Optical Communications (WOC)
Devin Brinkley, X - Alphabet's moonshot factory, USA

Visible Light Communication
Benjamin Azoulay, OLEDcomm, France

Ground-space Links: Key Role of Adaptive Optics and Current Challenges
Jean-Marc Conan, ONERA, France

Th1H • Prospects for the Usage of Millimetre Wave Bands

Thursday, 22 September, 08:30–10:15, *Delhi*

The use of radiations with wavelength from ten to one millimeter, commonly called millimeter waves and corresponding to the radio frequencies in the range 30 – 300 GHz, is often considered as a communication medium.

The increasing bandwidth requirement of new wireless applications 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
Clara Saraceno, Ruhr University Bochum, Germany

Th2H • Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO_2)

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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Plenary Speakers

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 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. 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 and conducted programs leading to the detection of hundreds of planets, including breakthrough results. He participated to numerous documentaries movies, articles, TV and radio interviews to share excitement and promote interest for science in general and in particular about exoplanets and life in the universe.

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 in constellations and for 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.

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 IET'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.

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 solutions. Since 2006, he's been responsible for steering ADVA's product innovation. As Chief Technology Officer, Dr. Christoph Glingener oversees the company's research and development program and directs its global operations. He's focused on shaping 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 fellowship 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 (QECDT), 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.

Tutorials

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
End-to-end Learning of Optical Communication Systems: A Beginner's Guide
We2C.1 – Wednesday, 21 September, 10:45–11:45, *Sydney*

Abstract: 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.

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 free-space 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 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

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, Science of Light, Germany
Stimulated Brillouin Scattering in Chiral Photonic Crystal Fibre
We4A.3 – Wednesday, 21 September, 16:15–16:45, *Samarkand + Osaka*

Radan Slavik, University of Southampton, UK
Thermal Sensitivity of Optical Fibres and How to Reduce it
Th1A.2 – Thursday, 22 September, 09:00–09:30, *Samarkand + Osaka*

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

Hektor Meier, Albis Optoelectronics AG, Switzerland
Avalanche Photodiode with High Dynamic Range, High Speed and Low Noise
Th2E.1 – Thursday, 22 September, 10:45–11:15, *Boston*

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*

Imran Khan, Max-Planck-Inst Physik des Lichts, Germany
Digital Signal Processing for CV-QKD
We4C.1 – Wednesday, 21 September, 15:45–16:15, *Sydney*

Yue-Kai Huang, NEC Laboratories America Inc., USA
Simultaneuous Sensing and Communication in Optical Fibers
We4C.5 – Wednesday, 21 September, 17:00–17:30, *Sydney*

Maximilian Schaedler, Huawei Munich Research Center, Germany
Nonlinear Component Equalization: A Comparison of Deep Neural Networks and Volterra Series
Th1C.1 – Thursday, 22 September, 08:30–09:00, *Sydney*

Vinod Bajaj, Technische Universiteit Delft, Netherlands
Performance Analysis of Recurrent Neural Network-based Digital Pre-Distortion for Optical Coherent Transmission
Th2C.1 – Thursday, 22 September, 10:45–11:15, *Sydney*

Adonis Bogris, University of West Attica, Greece
Machine Learning and Neuromorphic Computing Approaches for the Mitigation of Transmission Impairments in High Baud Rate Transmission System
Th2C.5 – Thursday, 22 September, 12:00–12:30, *Sydney*

SC5 – Theory of Optical Communications

Metodi P. Yankov, Danmarks Tekniske Universitet, Denmark
Recent Advances in Constellation Optimization for Fiber-optic Channels
Mo3D.4 – Monday, 19 September, 14:15–14:45, *Rio*

Tetsuya Hayashi, Sumitomo Electric Industries Ltd, Japan
Multi-core Fiber Technology from Design to Deployment
Mo4D.1 – Monday, 19 September, 15:45–16:15, *Rio*

Pierluigi Poggiolini, Politecnico di Torino, Italy
Closed Form Expressions of the Nonlinear Interference for UWB Systems
Tu1D.1 – Tuesday, 20 September, 08:30–09:00, *Rio*

Antonio Mecozzi, Universita degli Studi dell'Aquila, Italy
Use of Optical Coherent Detection for Environmental Monitoring
Tu3D.1 – Tuesday, 20 September, 13:30–14:00, *Rio*

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*

SC6 – Optical Transmission Systems

Oleg V. Sinkin, SubCom, USA
Strategies and Challenges in Designing Undersea Optical Links
We1D.3 – Wednesday, 21 September, 09:45–10:15, *Rio*

Hiroki 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*

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*

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

Philippe Chanclou, Orange Labs, France
Optical Access Solutions in Support of 5G and Beyond
Mo3C.1 – Monday, 19 September, 13:30–14:00, *Sydney*

Elaine Wong, University of Melbourne, Australia
Towards 6G: Machine Learning Driven Resource Allocation in Next Generation Optical Access Networks
Mo3C.5 – Monday, 19 September, 14:45–15:15, *Sydney*

Jun Shan Wey, Verizon Communications Inc, USA
Chartering the Future of Optical Access Networks
Mo4C.1 – Monday, 19 September, 15:45–16:15, *Sydney*

Hirotaka Nakamura, NTT Corporation, Japan
Key Components of Bidirectional Transceivers for Access Network at 100Gbit/s and Beyond
Tu1C.3 – Tuesday, 20 September, 09:00–09:30, *Sydney*

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
Datacenter Optical Transceivers in the Next Decade
Tu3C.2 – Tuesday, 20 September, 14:00–14:30, *Sydney*

Amitkumar 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 Photonic 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
Nanowire Flexible Light Emitting Diodes, Solar Cells and Piezosensors
Mo4G.4 – Monday, 19 September, 16:45–17:15, *Kairo*

Romain Quidant, ETH Zurich, Switzerland
Introducing Reconfigurability in Planar Metalenses
Tu1G.3 – Tuesday, 20 September, 09:00–09:30, *Kairo*

Angelos Xomalis, IESL.FORTH, Greece
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
Th1G.6 – Thursday, 22 September, 09:45–10:15, *Kairo*

Tracy Northup, Universität Innsbruck, Austria
Entanglement of Remote Trapped Ions
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

	San Francisco	Samarkand + Osaka	Singapore	Sydney	Rio	Boston	Shanghai	Kairo	Delhi
08:00–19:00	**Registration,** *Entrance Hall 1*								
09:00–10:30		WS02 • Role of Optical Network for Split Computing Between Edge and Cloud in Support of Ultra Low Latency Services I	WS04 • Adaptive Everything! Do Optical Networks Really Need More Flexibility? I	WS06 • F5G and Evolution Towards F6G I	WS08 • Life Above 100-GHz: Terahertz Device and System Challenges and Opportunities I	WS10 • On-chip Mid-IR and THz Combs I	WS12 • Heterogeneous Photonic Integrated Circuits I	IONS+ Supercharge Your Conference Experience	WS14 • Linear Optics - A Solution for Efficient Machine Learning, Hard Problems Solving, Quantum and Microwave Technologies? I
10:30–11:00	**Coffee Break,** *Foyer 2nd Floor*								
11:00–12:30		WS02 • Role of Optical Network for Split Computing Between Edge and Cloud in Support of Ultra Low Latency Services II	WS04 • Adaptive Everything! Do Optical Networks Really Need More Flexibility? II	WS06 • F5G and Evolution Towards F6G II	WS08 • Life Above 100-GHz: Terahertz Device and System Challenges and Opportunities II	WS10 • On-chip Mid-IR and THz Combs II	WS12 • Heterogeneous Photonic Integrated Circuits II	IONS+ Supercharge Your Conference Experience	WS14 • Linear Optics - A Solution for Efficient Machine Learning, Hard Problems Solving, Quantum and Microwave Technologies? II
12:30–14:00	**Lunch Break - On Your Own**								
14:00–15:30	WS01 • Optical Networks - Will They Destroy the Planet or Save Humanity? I	WS03 • The Path towards Terabit/s PONs: Enabling Multi Gbit/s Data Rate Services I	WS05 • Are Multi-band Optical Networks Simple Extensions of Traditional C-band Networks I	WS07 • Which Technologies Will be Needed for 6G? I	WS09 • Moving from Optical Components in RAN to Optical Components for RAN I	WS11 • Quantum Commpunication - Hype or Ripe? From QKD Networks to a Global Quantum Internet I	WS13 • Photonic and Electronic Co-integration Solutions I	IONS+ Supercharge Your Conference Experience	WS15 • Emerging Fiber Technologies For Transmission and Amplification I
15:30–16:00	**Coffee Break,** *Foyer 2nd Floor*								
16:00–17:30	WS01 • Optical Networks - Will They Destroy the Planet or Save Humanity? II	WS03 • The Path towards Terabit/s PONs: Enabling Multi Gbit/s Data Rate Services II	WS05 • Are Multi-band Optical Networks Simple Extensions of Traditional C-band Networks II	WS07 • Which Technologies Will be Needed for 6G? II	WS09 • Moving from Optical Components in RAN to Optical Components for RAN II	WS11 • Quantum Commpunication - Hype or Ripe? From QKD Networks to a Global Quantum Internet II	WS13 • Photonic and Electronic Co-integration Solutions II	IONS+ Supercharge Your Conference Experience	WS15 • Emerging Fiber Technologies For Transmission and Amplification II
18:00–19:00	Nobel Laureate Lecture								
19:00–21:00	**Get Together Reception,** *Foyer 2nd Floor*								

Agenda of Sessions — Monday, 19 September

	Samarkand + Osaka	Singapore	Sydney	Rio	Boston	Shanghai	Kairo	Delhi
08:00–18:00	**Registration,** *Entrance Hall 1*							
09:00–10:20	**Mo1 • Opening Remarks and Joint Plenary Session I,** *San Francisco*							
10:20–11:00	**Coffee Break,** *Exhibition Hall 1*							
11:00–12:00	**Mo2 • Joint Plenary Session II,** *San Francisco*							
12:00–13:30	**Lunch Break - On Your Own**							
13:30–15:15	**Mo3A • ML Driven Optical Networks** (ends at 15:00)	**Mo3B • Low Margin Optical Networks** (ends at 15:00)	**Mo3C • Optical Access Networks for Mobile Communications**	**Mo3D • Modulation and Coding**	**Mo3E • Swiss Symposium - Light and Time I**	**Mo3F • PIC Components**	**Mo3G • Multi-disciplinary Photonics**	**Mo3H • Symposium on 50 Years of Fibre Optics I**
15:15–15:45	**Coffee Break,** *Exhibition Hall 1*							
15:45–17:30	**Mo4A • Sensing with Optical Networks** (ends at 17:15)	**Mo4B • Edge Cloud and Low Latency** (ends at 17:15)	**Mo4C • Current Challenges for PON** (ends at 17:15)	**Mo4D • SDM and Submarine** (ends at 17:15)	**Mo4E • Swiss Symposium - Light and Time II**	**Mo4F • (Bi)CMOS Optoelectronics** (ends at 17:15)	**Mo4G • Novel Photonic Platforms and Sources I** (ends at 17:15)	**Mo4H • Symposium on 50 Years of Fibre Optics II**
17:30–18:30	**Mo5A • Poster Pitch Session I**	**Mo5B • Poster Pitch Session II**	**Mo5C • Poster Pitch Session III**				**Workshop on Photonic Startups & Entrepreneurship** (ends at 19:00)	
19:30–23:00	**Welcome Reception,** *Markthalle Basel*							

Agenda of Sessions — Tuesday, 20 September

	Samarkand + Osaka	Singapore	Sydney	Rio	Boston	Shanghai	Kairo	Delhi	Foyers
08:00–18:00	**Registration,** *Entrance Hall 1*								
08:30–10:15	**Tu1A • High-Baud Rate Optical Communication** (ends at 09:45)	**Tu1B • New Trends in Optical Networks**	**Tu1C • Quantum and Future Access Technologies**	**Tu1D • Nonlinear Transmission Modeling**	**Tu1E • Mid-IR Devices and Circuits** (ends at 9:30)	**Tu1F • Co-Packaging and Large Photoic Circuits**	**Tu1G • Metadevices and High-speed Photonics**	**Training Course on Integrated Photonic Technologies I**	
10:15–10:45	**Coffee Break,** *Exhibition Hall 1*								**Tu2 • Demo Zone,** *Foyer 3rd Floor*
10:45–12:30	**Exhibition Only**						**Special Workshop: Diversity in Action: Creating a Diverse and Inclusive Workplace, a Place for All to Belong**	**Training Course on Integrated Photonic Technologies II**	
12:30–13:30	**Lunch Break - On Your Own**								
13:30–15:15	**Tu3A • Fiber for High Capacity Transmission**	**Tu3B • Security**	**Tu3C • High Performance Computer Networks and High Throughput Transceivers**	**Tu3D • Sensing and Nonlinearity Tolerant Schemes** (ends at 14:45)	**Tu3E • Lasers for Silicon Photonics and Sensing**	**Tu3F • Satellite based Optical Freespace Communication I** (ends at 15:00)	**Tu3G • Novel Photonic Platforms and Sources II**	**Tu3H • Symposium: IEEE International Network Generations Optics Roadmap, 1st Edition** (starts at 13:00)	
15:15–15:45	**Coffee Break,** *Exhibition Hall 1*								
15:45–17:30	**Tu4A • Fiber Sensing and Characterization** (ends at 17:45)	**Tu4B • Symposium: Recent Advances in Submarine Systems**	**Tu4C • High-Speed PON Technologies** (ends at 17:15)	**Tu4D • Free-Space and Quantum Communication** (ends at 17:15)	**Tu4E • Advanced Modulators**	**Tu4F • FSO Communication** (ends at 17:15)	**Tu4G • Photonic Neural Networks** (ends at 17:15)	**13th European Photonic Integration Forum** (starts at 16:30, ends at 18:30)	
17:30–19:00				**Lab Automation Hackathon**					**Tu5 • Poster Session I,** *Foyer 2nd Floor*
19:30–23:00	**Gala Dinner,** *MS Rhystärn, Schifflände Basel*								

Agenda of Sessions — Wednesday, 21 September

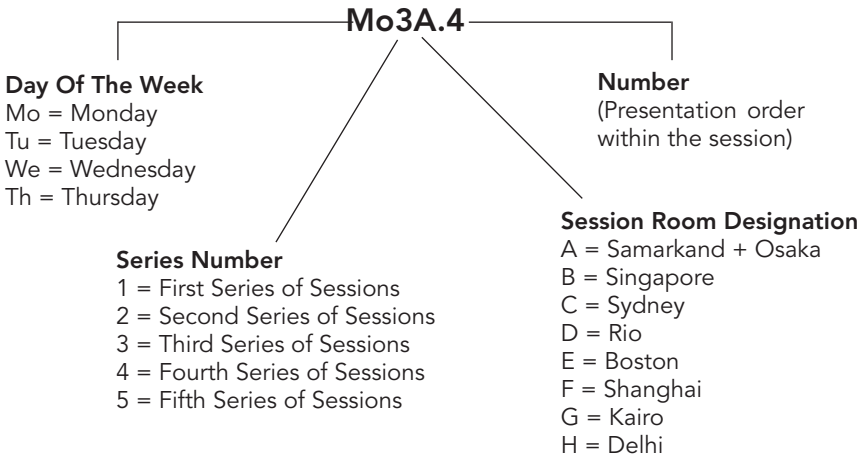
	Samarkand + Osaka	Singapore	Sydney	Rio	Boston	Shanghai	Kairo	Delhi	Foyers
08:00–17:30	**Registration,** *Entrance Hall 1*								
08:30–10:15	**We1A • Ultra-wideband Optical Systems** (ends at 10:00)	**We1B • Network Planning and Cost Efficiency** (ends at 10:00)	**We1C • Digital Optical Fiber Nonlinearity 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*								
10:45–12:30	**We2A • DCI and Metro Transmission Systems** (ends at 12:00)	**We2B • Control Plane and Automation**	**We2C • Deep Learning for Optical Fiber Communications**	**We2D • IM/DD & Short-Reach 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**								
13:30–15:15	**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*								
15:45–17:30	**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** (end 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**	**W4H • 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*

Agenda of Sessions — Thursday, 22 September

	Samarkand + Osaka	Singapore	Sydney	Rio	Boston	Shanghai	Kairo	Delhi
08:00–13:30	**Registration,** *Entrance Hall 1*							
08:30–10:15	**Th1A • Novel Fiber Fabrication Methods** (starts at 08:45, ends at 10:00)	**Th1B • Symposium: Free Space Optical Communication for Terrestrial & Space Applications I**	**Th1C • Novel Equalization Techniques**	**Th1D • SDM Transmission and Monitoring Systems**	**Th1E • High-speed Transmitter Devices**	**Th1F • Novel PICs and Applications**	**Th1G • Quantum Communication**	**Th1H • Symposium: Prospects for the Usage of Millimeter Wave Bands**
10:15–10:45	**Coffee Break,** *Foyer, 2nd Floor*							
10:45–12:30	**Th2A • Single Core and Multicore Fiber Amplifiers**	**Th2B • Symposium: Free Space Optical Communication for Terrestrial & Space Applications II**	**Th2C • High Baud Rate Transmission**	**Th2D • Intra-data Centre Networks**	**Th2E • Photodiodes and Photodetectors**	**Th2F • Non-Linear Devices and Packaging**	**Th2G • Quantum Photonics** (ends at 12:15)	**Th2H • Symposium: Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO_2)**
12:30–13:30	**Lunch Break - On Your Own**							
13:30–15:00	**Th3A • Postdeadline Session III**	**Th3B • Postdeadline Session I**	**Th3C • Postdeadline Session II**	**Th3D • Postdeadline Session IV**				
15:15–16:00	**Closing Ceremony,** *Singapore*							

Technical Programme

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.

Invited	Invited Presentation
Tutorial	Tutorial Presentation
Plenary	Plenary Presentation
Highly Scored	Highly Scored Paper

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[1]; [1]*President of ETH Zurich, Switzerland.*

18:05 Plenary
The Exoplanet Revolution, Didier Queloz[1]; [1]*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
Welcome Note, Jo Vergeat[1]; [1]*President of the Grand Council of Basel-Stadt, Switzerland.*

Mo1.1 • 09:20 Plenary
Optical Communications in Space: Challenges and Opportunities, Elisabetta Rugi Grond[1]; [1]*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 todays 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[1]; [1]*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[1]; [1]*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[1]; [1]*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

Samarkand + Osaka

13:30–15:00
Mo3A • ML Driven Optical Networks
Presider: Patricia Layec; Nokia Bell Labs, France

Mo3A.1 • 13:30 Tutorial
AI-Driven Digital Twin for Optical Networks, Qunbi Zhuge[1], Xiaomin Liu[1], Yihao Zhang[1], Meng Cai[1], Yichen Liu[1], Qizhi Qiu[1], Lilin Yi[1], Weisheng Hu[1]; [1]*Shanghai Jiao Tong Univ., China*. 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.

Singapore

13:30–15:00
Mo3B • Low Margin Optical Networks
Presider: Yvan Pointurier; Huawei, France

Mo3B.1 • 13:30 Invited
New Trends in Low Margin Optical Networks, Jelena Pesic[1]; [1]*Nokia Bell Labs, France*. Abstract not available.

Mo3B.2 • 14:00 ★ Highly Scored
Low-Margin Optical-Network Design with Multiple Physical-Layer Parameter Uncertainties, Oleg Karandin[1], Alessio Ferrari[2], Francesco Musumeci[1], Yvan Pointurier[2], Massimo Tornatore[1]; [1]*Politecnico di Milano, Italy;* [2]*Huawei 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.

Sydney

13:30–15:15
Mo3C • Optical Access Networks for Mobile Communications
Presider: Fabienne Saliou; Orange Labs, France

Mo3C.1 • 13:30 Invited
Optical Access Solutions in Support of 5G and Beyond, Philippe Chanclou[1], Gael Simon[2], Fabienne Saliou[2], Minqi Wang[2], André Bolloré[2]; [1]*Orange Labs, France;* [2]*Orange Innovation Lannion, France*. This invited paper reviews existing and coming optical access architectures and technologies for 5G and beyond mobile communication networks such as x-haul transport with a focus on the resiliency and low latency requirements.

Mo3C.2 • 14:00
Evaluating Bandwidth Efficiency and Latency of Scheduling Schemes for 5G Fronthaul Over TDM-PON, Sarvesh S. Bidkar[1], Konstantinos (Kostas) Christodoulopoulos[1], Thomas Pfeiffer[1], Rene Bonk[1]; [1]*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.

Rio

13:30–15:15
Mo3D • Modulation and Coding
Presider: Junho Cho; Nokia Bell Labs, USA

Mo3D.1 • 13:30 ★ Highly Scored
Reducing the Error Floor of the Sign-Preserving Min-Sum LDPC Decoder via Message Weighting of Low-Degree Variable Nodes, Lotte M. Paulissen[1], Alex Alvarado[1], Kaiquan Wu[1], Alexios Balatsoukas Stimming[1]; [1]*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 Miao[1], Lukas Rapp[1], Laurent Schmalen[1]; [1]*Karlsruher 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 Pan[1], yoones hashemi[1], Masoud Barakatain[1], Deyuan Chang[1], Frank R. Kschischang[2], zhuhong zhang[1], Chuandong Li[1]; [1]*Huawei Technologies Co Ltd, Canada;* [2]*Electrical 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.

Boston

13:30–15:15
Mo3E • Swiss Symposium - Light and Time I
Organiser: Steve Lecomte; CSEM, Switzerland

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.

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

Shanghai

13:30–15:15
Mo3F • PIC Components
Presider: Selina Farwell; Lumentum Operations Inc, UK

Mo3F.1 • 13:30
New SOA Based ASE Source Module with High Power, Flat Output Spectrum and Low PDL, Antonin Gallet[1], Nayla El Dahdah[1], Shuqi Yu[1,2], Iosif Demirtzioglou[1], Gabriel Charlet[1], Romain Brenot[1]; *[1]Huawei Technologies France S.A.S.U, France; [2]Telecom 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.

Mo3F.2 • 13:45
Large Aperture Receiver Based on Co-Packaged Micro-Lens and PD Arrays for Indoor GbE OWC Links, Yuchen Song[1], Chenhui Li[1], Ketema A. Mekonnen[1], Eduward Tangdiongga[1], Marc Spiegelberg[1], Oded Raz[1]; *[1]Technische Universiteit 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.

Mo3F.3 • 14:00 Invited
High-Bandwidth InP MZ/IQ Modulator PIC Ready for Practical Use, Yoshihiro Ogiso[1], Josuke Ozaki[1], Yasuaki Hashizume[1], Mitsuteru Ishikawa[1]; *[1]Nihon 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-GBd-class transmitters. The PIC exhibits superior optical properties with over 67 GHz bandwidth.

Kairo

13:30–15:15
Mo3G • Multi-disciplinary Photonics
Presider: Alexandros Emboras; ETH Zurich, Switzerland

Mo3G.1 • 13:30 Invited
Photonic Optimization: Approaching the Limits of Light Control, Alejandro Rodriguez[1]; *[1]Princeton Univ., USA.* Abstract not available.

Mo3G.2 • 14:00
Ultrafast Spiking Membrane III-v Laser Neuron on Si, Nikolaos P. Diamantopoulos[1], Suguru Yamaoka[1], Takuro Fujii[1], Hidetaka Nishi[1], Toru Segawa[1], Shinji Matsuo[1]; *[1]NTT Device Technology Labs, Japan.* We demonstrate a photonic spiking neuron based on an excitable membrane laser on Si. Both excitatory and inhibitory inputs up to 25 GBaud produce excitatory outputs with clearly-defined thresholds. <11 ps spike pulse widths and ~100 ps refractory periods have been achieved at ~15.3 pJ/spike.

Delhi

13:30–15:15
Mo3H • Symposium on 50 Years of Fibre Optics I
Organisers: Francesco Poletti; University of Southampton, UK
Tommy Geisler; OFS, Denmark

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.

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

Samarkand + Osaka

Mo3A • ML Driven Optical Networks—Continued

Mo3A.2 • 14:30 Invited

The Glass of Machine Learning for QoT Estimation Is Half Full, Matteo Lonardi[1,2], Jelena Pesic[2], Emmanuel Seve[1], Thierry Zami[3], Nicola Rossi[3]; [1]*Nokia Bell Labs, Italy;* [2]*Nokia, France;* [3]*Alcatel Submarine Networks, France.* We discuss an elastic optical network-based approach for evaluating QoT model substitution. Assessing QoT substitution is based on the fundamental idea that different QoT estimators should be examined by analyzing their impact integrated with the routing and spectrum allocation algorithm. Machine learning is no exception.

Singapore

Mo3B • Low Margin Optical Networks—Continued

Mo3B.3 • 14:15 ★ Highly Scored

Experimental Impact of Power Re-Optimization in a Mesh Network, Xin Yang[1], Alessio Ferrari[1], Nathalie Morette[1], Dylan LE Gac[1], Salma E. Landero[1], Gabriel Charlet[1], Yvan Pointurier[1]; [1]*Huawei Technologies France SASU, France.* We experimentally demonstrate the SNR degradation of existing services induced by loading new services in the network, and mitigate this degradation via 2 different power re-optimization strategies: static End-of-Life strategy and dynamic real-time strategy, yielding a 3.2 dB gain on the worst SNR.

Mo3B.4 • 14:30

Exploring Service Margins for Optical Spectrum Services, Kaida Kaeval[1,5], Frank Slyne[2], Sebastian Troia[3], Eoin Kenny[4], Jose-Juan Pedreno-Manresa[1], Sai Patri[1], Klaus Grobe[1], Daniel Kilper[2], Marco Ruffini[2], Gert Jervan[5]; [1]*ADVA, Germany;* [2]*The Univ. of Dublin Trinity College, Ireland;* [3]*Politecnico di Milano, Italy;* [4]*HEAnet Limited, Ireland;* [5]*TalTech, Estonia.* Reliable operation of Optical Spectrum Services requires a good understanding of service margins. We investigate the Optical Spectrum Service margins under varying channel-load and Optical Signal To Noise Ratio (OSNR) conditions in the Open Ireland testbed and verify the findings in the HEAnet production network.

Mo3B.5 • 14:45

Investigating Q-Drops and Their Probable Causes, Camille Delezoide[1], Petros Ramantanis[1], Patricia Layec[1]; [1]*Nokia Bell Labs, France.* We leverage data science to investigate the Q-drop phenomenon on a public optical network monitoring dataset. We show that Q-drops above 1 dB are common at network scale and correlated in at least 86% of cases with signs of packet loss.

Sydney

Mo3C • Optical Access Networks for Mobile Communications—Continued

Mo3C.3 • 14:15

Demonstration of 6.4-Tbit/s THz-Wave Signal Transmission Over 20-km Wired and 54-m Wireless Distance, Junjie Ding[1], Weiping Li[1], Long Zhang[1], Yanyi Wang[1], Jiaxuan Liu[1], Kaihui Wang[1], Li Zhao[1], Wen Zhou[1], Jiao Zhang[2], Min Zhu[2], Jianguo Yu[3], Feng Zhao[4], Jianjun Yu[1,2]; [1]*Fudan Univ., China;* [2]*Purple Mountain Laboratories, China;* [3]*Beijing Univ. of Posts and Telecommunications, China;* [4]*Xi'an Univ. of Posts and Telecommunications, China.* The experimental demonstration of the ultra-large-capacity THz-over-fiber transmission over 20-km wired and 54-m wireless distance in an 80-channel WDM system is successfully realized, achieving a record line rate of 6.4 Tbit/s.

Mo3C.4 • 14:30

Real-Time and DSP-Free 100 Gbit/s/Lambda PAM-4 Fiber Link Supporting 4λ Operation with a Common Fiber Amplifier for Future Mobile X-Haul and Point to Point Access Networks, Jeremy Potet[1,2], Mathilde Gay[2], Laurent Bramerie[2], Monique Thual[2], Fabienne Saliou[1], Gaël Simon[1], Philippe Chanclou[1]; [1]*Orange, France;* [2]*Fonctions Optiques pour les Technologies de l'information, France.* We demonstrate a real time and DSP-free 100 Gbit/s/lambda fiber link supporting 4λ operation for future generation mobile X-haul reaching 16.15 dB of channel insertion losses and 30 km, with the use of a common O-band fiber amplifier and transmitter analog pre-equalization.

Mo3C.5 • 14:45 Invited

Towards 6G: Machine Learning Driven Resource Allocation in Next Generation Optical Access Networks, Elaine Wong[1], Lihua Ruan[2]; [1]*Dept of Electrical and Electronic Engineering, Univ. of Melbourne, Australia;* [2]*Chinese Univ. of Hong Kong, China.* 6G networks will deliver immersive applications that bridge real and digital worlds. The next-generation optical access network is a potential optical transport solution. In view of dynamic network conditions, we propose a machine learning driven solution that rapidly self-adapts to support new 6G applications.

Rio

Mo3D • Modulation and Coding—Continued

Mo3D.4 • 14:15 Invited

Recent Advances in Constellation Optimization for Fiber-Optic Channels, Metodi P. Yankov[1], Ognjen Jovanovic[1], Darko Zibar[1], Francesco Da Ros[1]; [1]*Department of Electrical and Photonics Engineering, Danmarks Tekniske Universitet, Denmark.* The autoencoder concept for geometric constellation shaping is discussed. Applications in coherent optical fiber communications are presented. Several popular training algorithms are compared. The quantization problem of finite precision DAC and ADC is addressed.

Mo3D.5 • 14:45

Optimization of Geometric Constellation Shaping for Wiener Phase Noise Channels with Varying Channel Parameters, Andrej Rode[1], Laurent Schmalen[1]; [1]*Karlsruhe Inst. of Technology, Germany.* We present a novel method to investigate the effects of varying channel parameters on geometrically shaped constellations for communication systems employing the blind phase search algorithm. We show that introduced asymmetries significantly improve performance if adapted to changing channel parameters.

Boston

Mo3E • Swiss Symposium - Light and Time I—Continued

Shanghai

Mo3F • PIC Components—Continued

Mo3F.4 • 14:30
Wafer-Scale Fabrication of low-Loss Waveguides in Lithium Niobate on Insulator (LNOI) Integrated Photonics Platform, Jacopo Leo[1], Mozhgan Hayati[1], Farnaz Ebrahimi Agri[1], Zyad Haddad[1], Gregory Choong[1], Yves Petremand[1], Ivan Prieto[1], Olivier Dubochet[1], Michel Despont[1], Hamed Sattari[1], Amir Ghadimi[1]; *[1]Centre 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 Georgieva[1], Pascal Seiler[1,2], Christian Mai[2], Anna Peczek[2], Klaus Petermann[1], Lars Zimmermann[1,2]; *[1]Technische Universität Berlin, Germany; [2]IHP - Leibnitz 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.

Kairo

Mo3G • Multi-disciplinary Photonics—Continued

Mo3G.3 • 14:15
Generation of Strong Parametric Fluorescence in a Highly-Nonlinear Silicon Nitride Waveguide with a Simple Pulsed Pump Source, Ping Zhao[1], Zhichao Ye[1], Magnus Karlsson[1], Victor Torres-Company[1], Peter Andrekson[1]; *[1]Chalmers 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 Zellweger[1,2], Bojun Cheng[1], Konstantin Malchow[3], Aymeric Leray[3], Jan Aeschlimann[2], Mathieu Luisier[2], Alexandros Emboras[2], Alexandre Bouhelier[3], Juerg Leuthold[1]; *[1]Inst. of Electromagnetic Fields, Eidgenossische Technische Hochschule Zurich, Switzerland; [2]Integrated Systems Laboratory, Eidgenossische Technische Hochschule Zurich, Switzerland; [3]Laboratoire 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 Invited
Topological Photonic Devices, Mercedeh Khajavikhan[1]; *[1]Univ. of Southern California, USA.* Abstract not available.

Delhi

Mo3H • Symposium on 50 Years of Fibre Optics I—Continued

Samarkand + Osaka	Singapore	Sydney	Rio
Mo3A • ML Driven Optical Networks—Continued	**Mo3B • Low Margin Optical Networks—Continued**	**Mo3C • Optical Access Networks for Mobile Communications—Continued**	**Mo3D • Modulation and Coding—Continued**

Mo3D.6 • 15:00
Nonlinear Fiber Transmission of Compressed Shaping Signals, Tsuyoshi Yoshida[1,2], Takashi Inoue[3], Koji Igarashi[2], Masashi Binkai[1], Yoshiaki Konishi[1], Naoki Suzuki[1], Magnus Karlsson[4], Erik Agrell[4]; *[1]Information Technology R&D Center, Mitsubishi Electric Corporation, Japan; [2]Graduate School of Engineering, Osaka Univ., Japan; [3]National Inst. of Advanced Industrial Science and Technology, Japan; [4]Fiber 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.

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

Boston	Shanghai	Kairo	Delhi
Mo3E • Swiss Symposium - Light and Time I—Continued	**Mo3F • PIC Components—Continued**	**Mo3G • Multi-disciplinary Photonics—Continued**	**Mo3H • Symposium on 50 Years of Fibre Optics I—Continued**

Mo3F.6 • 15:00
Impact of Seed Annealing on the Reliability of Monolithic GaAs/Si p-n Diode Optical Phase Shifters, Artemisia Tsiara[1], Younghyun Kim[2], Didit Yudistira[1], Bernadette Kunert[1], Marina Baryshnikova[1], Marianna Pantouvaki[3], Joris Van Campenhout[1], Kristof Croes[1]; *[1]Interuniversitair Micro-Elektronica Centrum, Belgium; [2]Department of Photonics and Nanoelectronics, Hanyang Univ. College of Science and Convergence Technology, Korea (the Republic of); [3]Microsoft 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 $V_{\pi}.L_{\pi}$ with no stress temperature dependence.

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

Samarkand + Osaka

15:45–17:15
Mo4A • Sensing with Optical Networks
Presider: Bernhard Schrenk; AIT Austrian Inst. of Technology, Austria

Mo4A.1 • 15:45
Fibre Type Identification: Alleviating Ambiguities, Emmanuel Seve[1], Sebastien Bigo[1], Patricia Layec[1]; [1]*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[1], Neil Parkin[2], Roland Ryf[1], Asif Iqbal[2], Paul Wright[2], Kristian Farrow[2], Nicolas K. Fontaine[1], Erik Borjeson[3], KW Kim[1], Lauren Dallachiesa[1], Haoshuo Chen[1], Per Larsson-Edefors[3], Andrew Lord[2], David T. Neilson[1]; [1]*Nokia Bell Labs, USA;* [2]*BT, UK;* [3]*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 Kamalov[1]; [1]*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.

Singapore

15:45–17:15
Mo4B • Edge Cloud and Low Latency
Presider: Raul Muñoz; CTTC, Spain

Mo4B.1 • 15:45 Tutorial
Resource Orchestration in Support of Edge Computing in Optical Networks, Emmanouel Varvarigos[1]; [1]*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.

Sydney

15:45–17:15
Mo4C • Current Challenges for PON
Presider: Satoshi Yoshima; Japan

Mo4C.1 • 15:45 Invited
Chartering the Future of Optical Access Networks, Jun Shan Wey[1], Denis Khotimsky[1]; [1]*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
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[1], Fabienne Saliou[1], Jeremy Potet[1], Gael Simon[1], Philippe Chanclou[1], Flávio Nogueira Sampaio[1]; [1]*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.

Rio

15:45–17:15
Mo4D • SDM and Submarine
Presider: Cristian Antonelli; Universita degli Studi dell'Aquila, Italy

Mo4D.1 • 15:45 Invited
Multi-Core Fiber Technology from Design to Deployment, Tetsuya Hayashi[1]; [1]*Sumitomo Electric Industries Ltd, Japan.* Multi-core fiber (MCF) technology has advanced considerably since the capacity limit of the single-mode fiber had been posed. This talk will review such advancements in the design aspects and deployment trials of MCFs, which have demonstrated technical feasibility of MCF technology in the field.

Mo4D.2 • 16:15
Modulation-Format Dependent Impact of Modal Dispersion on Cross-Phase Modulation in SDM Transmission, Chiara Lasagni[2], Paolo Serena[1], Alberto Bononi[1], Cristian Antonelli[2], Antonio Mecozzi[2]; [1]*Universita degli Studi di Parma, Italy;* [2]*Universita degli Studi dell'Aquila Dipartimento di Scienze Fisiche e Chimiche, 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.

Boston

15:45–17:30
Mo4E • Swiss Symposium - Light and Time II
Organiser: Steve Lecomte; CSEM, Switzerland

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.

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

Shanghai

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

Mo4F.1 • 15:45
Class-80 InP-Based High-Bandwidth Coherent Driver Modulator with Flexible Printed Circuit RF Interface, Josuke Ozaki[1], Yoshihiro Ogiso[1], Yasuaki Hashizume[1], Hiroshi Yamazaki[3], Kazuya Nagashima[2], Mitsuteru Ishikawa[1]; *[1]NTT Device Innovation Center, Nippon Telegraph and Telephone Corporation, Japan; [2]Telecommunications & Energy Laboratories, Furukawa Denki Kogyo Kabushiki Kaisha, Japan; [3]NTT Device Technology Labs, Nippon Telegraph and Telephone Corporation, 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 Singh[1], Joris Van Kerrebrouck[1], Piet Demeester[1], Xin Yin[1], Guy Torfs[1]; *[1]IDLab 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 mm^2 and a power consumption of 45 mW. Link experiments are conducted with QAM signals.

Mo4F.3 • 16:15 Invited
CMOS Transceiver Circuits for Energy Efficient Silicon Photonic Interconnects, Peng Yan[1], Po-Hsuan Chang[1], Anirban Samanta[2], Chaerin Hong[1], Hyungryul Kang[1], Dedeepya Annabattuni[1], Ankur Kumar[1], Yang-Hang Fan[1], Ruida Liu[1], S. J. Ben Yoo[2], Samuel Palermo[1]; *[1]Texas A&M Univ., USA; [2]Univ. of California Davis College of Engineering, USA.* Energy efficient transceivers are necessary to scale optical interconnect performance well below 500fJ/b. We discuss our circuit design work in CMOS transmitter and receiver front-ends optimized for silicon photonic microring resonator-based wavelength division multiplexing interconnects.

Kairo

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

Mo4G.1 • 15:45 Invited
3D Laser Printing Based on Two-Step Absorption, Martin Wegener[1]; *[1]Karlsruher 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.

Mo4G.2 • 16:15
Sefl-Assembled Dewetting as a Fabrication Platform for Photonics Applications, Pierre-Luc Piveteau[1], Louis Martin-Monier[1,2], Tapajoyti Das Gupta[1,3], Bastien Schyrr[1], William Esposito[1], Fabien Sorin[1]; *[1]Ecole Polytechnique Federale de Lausanne Faculte des Sciences et Techniques de l'Ingenieur, Switzerland; [2]Massachusetts Inst. of Technology, USA; [3]Indian 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 metagrating for index sensing.

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

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.

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

Samarkand + Osaka

Mo4A • Sensing with Optical Networks—Continued

Mo4A.4 • 16:45 Invited

Sensing Applications in Deployed Telecommunication Fiber Infrastructures, Pierpaolo Boffi[1]; *[1]Politecnico di Milano, Italy.* TLC-compatible coherent interferometric strategies applied to already deployed fiber networks are presented to provide not only civil 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.

17:30–18:30
Mo5A • Poster Pitch Session I
Presider: Juerg Leuthold, ETH Zurich, Switzerland

Singapore

Mo4B • Edge Cloud and Low Latency—Continued

Mo4B.2 • 16:45

Schedulers Synchronization Supporting Ultra Reliable Low Latency Communications (URLLC) in Cloud-RAN Over Virtualised Mesh PON, Sandip Das[1], Frank Slyne[1], Daniel Kilper[1], Marco Ruffini[1]; *[1]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.

Mo4B.3 • 17:00

MAGC-RSA: Multi-Agent Graph Convolutional Reinforcement Learning for Distributed Routing and Spectrum Assignment in Elastic Optical Networks, Huy Q. Tran[1], Omar Houidi[2], Javier Errea-Moreno[1], Dominique Verchere[1], Djamal Zeghlache[2]; *[1]Nokia Bell Labs, USA; [2]Telecom SudParis, France.* This paper proposes MAGC-RSA, a Multi-Agent Graph Convolutional Reinforcement Learning approach, to solve the Routing and Spectrum Assignment (RSA) problem in a distributed manner. A blocking probability reduction of 80% can be achieved compared to the Shortest Path First-Fit approach.

17:30–18:30
Mo5B • Poster Pitch Session II
Presider: Niels Quack, University of Sydney, Australia

Sydney

Mo4C • Current Challenges for PON—Continued

Mo4C.3 • 16:30

Over 40-dB Link Budget, Burst-Mode Digital Coherent Detection of Single Wavelength 50-Gbps Multilevel-CPFSK Signals Generated by EA-DFB-LD Based Transmitter, Ryo Koma[1], Kazutaka Hara[1], Takuya Kanai[1], Jun-ichi Kani[1], Tomoaki Yoshida[1]; *[1]NTT Corporation, Japan.* This paper evaluates the link budget of single wavelength 50-Gbps 4-level CPFSK signals generated by simple EA-DFB-SOA based transmitter in digital coherent reception based optical access networks. We demonstrate world's first high link budget detection of over 40-dB.

Mo4C.4 • 16:45

Triple Coexistence of PON Technologies: Experimentation of G-PON, XGS-PON and 50G(S)-PON Over a Class C+ ODN, Fabienne Saliou[1], Georges Gaillard[1], Gael Simon[1], Stephane Le Huerou[1], Jeremy Potet[1], Philippe Chanclou[1]; *[1]Orange, France.* With measurements from the field and commercial MPM 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.

Mo4C.5 • 17:00

Experimental Analysis of TDEC for Higher Speed PON Including Linear Equalization, Gael Simon[1], Flávio Nogueira Sampaio[1], Fabienne Saliou[1], Jérémy Potet[1], Philippe Chanclou[1]; *[1]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.

17:30–18:30
Mo5C • Poster Pitch Session III
Presider: Bert Offrein, IBM Research Zurich, Switzerland

Rio

Mo4D • SDM and Submarine—Continued

Mo4D.3 • 16:30

Increase of Capacity with Bidirectional Transmission Using 4-Core-or-More MCF and MC-EDFA in Submarine Systems, Shoma Tateno[1], Hitoshi Takeshita[1], Kohei Hosokawa[1], Emmanuel Le Taillandier de Gabory[1]; *[1]Nihon Denki Kabushiki Kaisha Tamagawa Jigyosho, Japan.* We analytically demonstrate that bidirectional multicore transmission design with bidirectional MC-EDFA increases the capacity of submarine cables, by 5.0 times, compared to conventional SCF, for 3,000 km-long regional Asian systems using 6-core MCF and 2.3 times for 9,000 km-long transpacific systems using 4-core MCF.

Mo4D.4 • 16:45

Modelling of Cable Capacity and Relative Cost/bit Between Amplification Options for Submarine MCF Systems, John D. Downie[1], Yongmin Jung[2], Sergejs Makovejs[1], Merrion Edwards[1], David Richardson[2]; *[1]Corning Inc, USA; [2]Univ. of Southampton, UK.* We examine amplification options for repeatered submarine systems using multicore transmission fibre in the context of relative cable capacity and system cost/bit. Multicore EDFAs using either core-pumping or cladding-pumping could offer lower cost/bit than parallel single-core EDFAs but cladding-pumping may reduce cable capacities.

Mo4D.5 • 17:00

Capacity Prediction from Commissioning Parameters of Subsea Open Cables, Joana Girard-Jollet[1], Jean-Christophe Antona[1], Alexis Carbo Meseguer[1], Matteo Lonardi[2], Samuel Olsson[3], Vincent Letellier[1], Olivier Courtois[1]; *[1]Alcatel Submarine Networks, France; [2]nokia bell labs, France; [3]Nokia, USA.* We numerically assess the impact of 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.

Boston

Mo4E • Swiss Symposium - Light and Time II—Continued

Shanghai

Mo4F • (Bi)CMOS Optoelectronics—Continued

Mo4F.4 • 16:45 ★ Highly Scored

First Demonstration of an O-Band Coherent Link for Intra-Data Center Applications, Aaron Maharry[1], Junqian Liu[1], Stephen Misak[1], Hector Andrade[1], Luis A. Valenzuela[1], Giovanni Gilardi[2], Hao-Hsiang Liao[2], Ansheng Liu[2], Yuliya A. Akulova[2], Larry Coldren[1], James F. Buckwalter[1], Clint L. Schow[1]; *[1]Univ. of California Santa Barbara, USA; [2]Intel 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 Chang[1], Mingye Fu[2], Peng Yan[1], Anirban Samanta[2], Mehmet Berkay On[2], Yuanming Zhu[1], S. J. Ben Yoo[2], Samuel Palermo[1]; *[1]Texas A&M Univ., USA; [2]Univ. 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.

Kairo

Mo4G • Novel Photonic Platforms and Sources I—Continued

Mo4G.3 • 16:30

A Path Towards Attojoule Cryogenic Communication, Matteo Cherchi[1], Emma Mykkänen[1], Antti Kemmpinen[1], Kirsi Tappura[1], Joonas Govenius[1], Mika Prunnila[1], Giovanni Delrosso[1], Teemu Hakkarainen[2], Jukka Viheriälä[2], Mario Castañeda[3], Mark Bieler[4], Stephan Steinhauer[5], Val Zwiller[5,3], Stefan Koepfli[6], Juerg Leuthold[6], Eva De Leo[7]; *[1]VTT Technical Research Centre of Finland, Finland; [2]ORC, Tampereen yliopisto, Finland; [3]Single Quantum B V, Netherlands; [4]Physikalisch-Technische Bundesanstalt, Germany; [5]Kungliga Tekniska Hogskolan, Sweden; [6]Eidgenossische Technische Hochschule Zurich, Switzerland; [7]Polariton 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 Tchernycheva[1]; *[1]IEF, France.* Abstract not available.

Delhi

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

19:30–23:00 Welcome Reception, *Markthalle Basel, Steinentorberg 20, 4051 Basel*

Samarkand + Osaka	Singapore	Sydney	Rio

08:00–18:00 Registration, *Entrance Hall 1*

08:30–09:45
Tu1A • High-Baud Rate Optical Communication
Presider: Oskars Ozolins; RISE Research Inst.s of Sweden AB, Sweden

Tu1A.1 • 08:30 ★ Highly Scored

Real-Time 10-λ×800-Gb/s Sub-Carrier-Multiplexing 95-GBd DP-64QAM-PCS Transmission Over 2018-km G.654.E Fibre With Pure Backward Distributed Raman Amplification, Dawei Ge[1], Houyuan Zhang[2], Cong Yu[3], Dong Wang[1], Dechao Zhang[1], Ruichun Wang[4], Yunbo Li[1], Sheng Liu[1], Shan Cao[1], Liang Mei[3], Hui Zhou[3], Liuyan Han[1], Hongjun Li[2], Lixin Gu[4], Jihong Zhu[4], Xiaodong Duan[1], Han Li[1]; [1]*China Mobile Research Inst., China;* [2]*ZTE Corp, China;* [3]*FiberHome Technologies, China;* [4]*Yangtze Optical Fibre and Cable Joint Stock Ltd Co, China.* With the help of pure backward distributed Raman amplification and ultra-low-loss G.654.E fibre, for the first time, a record 2018-km transmission with OSNR margin of 3.39 dB can be achieved by 10-λ×800-Gb/s sub-carrier-multiplexing 95-GBd DP-64QAM-PCS signals at 112.5-GHz grid.

Tu1A.2 • 08:45

Optical Performance Monitoring of Digital Subcarrier Multiplexed Signals Using Amplitude Modulation Pilot Tone, Junho Chang[1], Xuefeng Tang[1], Choloong Hahn[1], Zhiping Jiang[1]; [1]*Huawei Technologies Canada, Canada.* 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.

08:30–10:15
Tu1B • New Trends in Optical Networks
Presider: Jesse Simsarian; Nokia Bell Labs, USA

Tu1B.1 • 08:30 Invited

New Trends in Photonic Switching and Optical Network Architecture for Data Centre and Computing, S. J. Ben Yoo[1]; [1]*Univ. of California Davis, USA.* "AI/ML for data centres" and "data centres for AI/ML" are defining new trends in cloud computing. Disaggregated heterogeneous reconfigurable computing systems realized by photonic interconnects and photonic switching expect greatly enhanced throughput and energy-efficiency for AI/ML workloads, especially when aided by an AI/ML control plane.

08:30–10:15
Tu1C • Quantum and Future Access Technologies
Presider: Michela Svaluto Moreolo; Ctr Tecnològic de Telecom de Catalunya, Spain

Tu1C.1 • 08:30

Demonstration of Continuous Multiple Access with Imagerejection Coherent Receiver and DML Transmitters, Jeison Tabares[1], Miquel Masanas[1], Ivan N. Cano[2], Josep Prat[1]; [1]*Universitat Politècnica de Catalunya, Spain;* [2]*Huawei Technologies Deutschland GmbH, Germany.* We demonstrate a UD-WDM PON using DML transmitters with multilevel intensity modulation, both in base-band and RF, and a spectrally-efficient heterodyne receiver. We provide comparison with a homodyne receiver. Two users at the same IF are detected simultaneously avoiding image frequency interference while minimizing complexity.

Tu1C.2 • 08:45

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[1], Marcos Troncoso-Costas[2], Liam P. Barry[1], Colm Browning[1]; [1]*Dublin City Univ., Ireland;* [2]*EI Telecommunication, Universidade 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.

08:30–10:15
Tu1D • Nonlinear Transmission Modeling
Presider: Rene-Jean Essiambre; Nokia Corporation, USA

Tu1D.1 • 08:30 Invited

Closed Form Expressions of the Nonlinear Interference for UWB Systems, Pierluigi Poggiolini[1], Mehdi Ranjbar[2]; [1]*Politecnico di Torino, Italy;* [2]*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.

Boston	Shanghai	Kairo	Delhi

08:00–18:00 Registration, *Entrance Hall 1*

08:30–09:30
Tu1E • Mid-IR Devices and Circuits
Presider: Jörg Wieland; Tetra Semiconductors Ltd, Switzerland

Tu1E.1 • 08:30 Tutorial

Silicon and Germanium Mid-IR Devices and Circuits, Goran Mashanovich[1]; [1]*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.

08:30–10:15
Tu1F • Co-Packaging and Large Photonic Circuits
Presider: Lars Zimmermann; IHP GmbH, Germany

Tu1F.1 • 08:30 Invited

Key Technology Enablers for Co-Packaged Optics, Karl Muth[1], Vivek Raghuraman[1]; [1]*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.

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

Tu1G.1 • 08:30

Plasmonic 100-GHz Electro-Optic Modulators for Cryogenic Applications, Patrick Habegger[1,2], Yannik Horst[2], Stefan Köpfli[2], Manuel Kohli[2], Eva De Leo[1], Dominik Bisang[2], Marcel Destraz[1], Valentino Tedaldi[1], Norbert Meier[1], Nino Del Medico[1], Wei Wang[2,1], Claudia Hoessbacher[1], Benedikt Baeuerle[1], Wolfgang Heni[1], Juerg Leuthold[2,1]; [1]*Polariton Technologies AG, Switzerland;* [2]*ITET, Eidgenossische Technische Hochschule Zurich, Switzerland.* We demonstrate an energy-efficient, 100-GHz plasmonic modulator operating at 4K for beyond 128 GBd 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 E. Schneider[1], Philipp Täschler[1], Mathieu Bertrand[1], Filippos Kapsalidis[1], Mattias Beck[1], Jérôme Faist[1]; [1]*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-with at half-maximum of 558 fs when isolated, which corresponds to the expected Fourier-transform limited pulse-width.

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
Jurgen Van Erps; Vrije Universiteit Brussel, Belgium

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

Samarkand + Osaka

Tu1A • High-Baud Rate Optical Communication—Continued

Tu1A.3 • 09:00 Invited

Is It Meaningful to Pursue Higher Symbol Rate Beyond Bandwidth Constraint for Short-Reach Interconnects?, Di Che[1]; [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.

Tu1A.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, Paikun Zhu[2], Yuki Yoshida[2], Atsushi Kanno[2], Ken-ichi Kitayama[1,2]; [1]*Hamamatsu Photonics Kabushiki Kaisha Chuo Kenkyujo, Japan;* [2]*Kokuritsu Kenkyu Kaihatsu Hojin 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.

Singapore

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 Pavon-Marino[1,2], Nina Skorin-Kapov[3], Antonio Napoli[4]; [1]*Universidad Politécnica de Cartagena, Spain;* [2]*E-lihgthouse Network Solutions, Spain;* [3]*Univ. Center of Defense, San Javier Air Force Base, Spain;* [4]*Infinera Corp, Germany.* We present the first generalized dimensioning algorithm for optical networks with subcarrier-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[2], Eric Bernier[1]; [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

Accelerate Optical Network Modernization Through Quantum-Inspired Digital Annealing, Masahiko Sugimura[1], Mikinori Kobayashi[1,2], Hidetoshi Matsumura[1], Xi Wang[3], Paparao Palacharla[3]; [1]*Fujitsu Consulting (Canada) Inc., Canada;* [2]*NTT Electronics Cross Technologies Corp., Japan;* [3]*Fujitsu Network Communications Inc., USA.* In order to optimize migration plans for speedy network modernization, we developed an optimization problem formulation to utilize Fujitsu Digital Annealer. Compared to formulations tailored to commercial MIP solvers, our method found more optimal migration plans by up to 35%.

Sydney

Tu1C • Quantum and Future Access Technologies—Continued

Tu1C.3 • 09:00 Invited

Key Components of Bidirectional Transceivers for Access Network at 100Gbit/s and Beyond, Hirotaka Nakamura[1]; [1]*NTT Corporation, Japan.* 100Gbit/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 Invited

Is There Room for Quantum Photons in my Access Network?, Annachiara Pagano[1], Antonio Manzalini[1], Maurizio Valvo[1]; [1]*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.

Rio

Tu1D • Nonlinear Transmission Modeling—Continued

Tu1D.2 • 09:00 ★ Highly Scored

Generalized Raman Scattering Model and Its Application to Closed-Form GN Model Expressions Beyond the C+L Band, Chiara Lasagni[1], Paolo Serena[3], Alberto Bononi[3], Jean-Christophe Antona[2]; [1]*Universita degli Studi dell'Aquila Dipartimento di Scienze Fisiche e Chimiche, Italy;* [2]*Alcatel 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 Blugia[1], Eric Sillekens[1], A Vasylchenkova[1], Robert Killey[1], Polina Bayvel[1], Lidia Galdino[1]; [1]*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 Mecozzi[2], Cristian Antonelli[2], Marco Santagiustina[1]; [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 NLIN 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.

Tu1E • Mid-IR Devices and Circuits—Continued

Tu1F • Co-Packaging and Large Photonic Circuits—Continued

Tu1F.2 • 09:00
An 800 Gb/s, 16 Channel, VCSEL-Based, co-Packaged Transceiver With Fast Laser Sparing, Daniel Kuchta[1], Mounir Meghelli[1], Petar Pepeljugoski[1], Laurent Schares[1], Mark Schultz[1], Pavlos Maniotis[1], Paul Fortier[2], Charles Bureau[2], Marc-Olivier Pion[2], Yvan Cossette[2], Guillaume Jutras[2], Bory Sow[2], Bakul Parikh[3], Steve Ostrander[3], Shidong Li[3], Dale Becker[3], Faezah Gholami[3], Harry Bagheri[3], Frank Flens[4], Greta Light[4], Bill Wang[4]; *[1]IBM TJ Watson Research Center, USA; [2]IBM Bromont, Canada; [3]IBM Systems, USA; [4]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 Noriki[2,1], Akio Ukita[2], Koichi Takemura[2], Satoshi Suda[2,1], Takayuki Kurosu[2,1], Yasuhiro Ibusuki[2], Isao Tamai[2], Daisuke Shimura[2], Yosuke Onawa[2], Hiroki Yaegashi[2], Takeru Amano[2,1]; *[1]Natl Inst of Adv Industrial Sci & Tech, Japan; [2]Photonics 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 Invited
Photonic Circuits for Accelerated Computing Systems, Benjamin G. Lee[1]; *[1]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 • Metadevices and High-speed Photonics—Continued

Tu1G.3 • 09:00 Invited
Introducing Reconfigurability in Planar Metalenses, Romain Quidant[1]; *[1]ETH 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 Xomalis[1]; *[1]IESL.FORTH, Greece.* Abstract not available.

Training Course on Integrated Photonic Technologies I—Continued

Samarkand + Osaka	Singapore	Sydney	Rio
Tu1A • High-Baud Rate Optical Communication—Continued	**Tu1B • New Trends in Optical Networks—Continued**	**Tu1C • Quantum and Future Access Technologies—Continued**	**Tu1D • Nonlinear Transmission Modeling—Continued**
	Tu1B.5 • 09:45 Invited **Time Sensitive Networking for 5G and Beyond,** Jun Terada[1]; [1]*NTT Access Service Systems Laboratories, Japan.* Abstract not available.		**Tu1D.5 • 09:45** **Analytical SNR Prediction in Long-Haul Optical Transmission Using General Dual-Polarization 4D Formats,** Zhiwei Liang[1], Bin Chen[1], Yi Lei[1], Gabriele Liga[2], Alex Alvarado[2]; [1]*Hefei Univ. of Technology, China;* [2]*Technische 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.
		Tu1C.5 • 10:00 **DAC/ADC-Free 65536-Level Quantum Noise Stream Cipher for Secure Fiber Transmission Based on Delta-Sigma Modulation,** Hanwen Luo[1,2], Linsheng Zhong[1,2], Shenmao Zhang[1,2], Xiaoxiao Dai[1,2], Lei Deng[1,2], Deming Liu[1,2], Mengfan Cheng[1,2], Qi Yang[1,2]; [1]*Huazhong Univ. of Science and Technology, China;* [2]*Shenzhen Huazhong Univ. of Science and Technology Research Institue, 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.6 • 10:00** **Closed-Form Expressions for Fiber-Nonlinearity-Based Longitudinal Power Profile Estimation Methods,** Takeo Sasai[1], Etsushi Yamazaki[1], Masanori Nakamura[1], Yoshiaki Kisaka[1]; [1]*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

Boston	Shanghai	Kairo	Delhi
Tu1E • Mid-IR Devices and Circuits—Continued	**Tu1F • Co-Packaging and Large Photonic Circuits—Continued**	**Tu1G • Metadevices and High-speed Photonics—Continued**	**Training Course on Integrated Photonic Technologies I—Continued**
	Tu1F.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 Matsumoto[1], Ryotaro Konoike[1], hiroyuki Matsuura[1], Keijiro Suzuki[1], Takashi Inoue[1], Kazuhiro Ikeda[1], Shu Namiki[1], Ken-ichi Sato[1]; [1]*National 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.	**Tu1G.5 • 10:00** ★ Highly Scored **Optically Reconfigurable Ferroelectric Metasurfaces,** Artemios Karvounis[1], Helena Weigand[1], Martin Varga[1], Viola Valentina Vogler Neuling[1], Rachel Grange[1]; [1]*Eidgenossische 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 Romanyshyn; 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, Netherlands* *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

Samarkand + Osaka

13:30–15:15
Tu3A • Fiber for High Capacity Transmission
Presider: Tommy Geisler; OFS FITEL DENMARK ApS, Denmark

Tu3A.1 • 13:30 Invited
Single-Mode Fibers with Reduced Cladding and/or Coating Diameters, Pierre Sillard[1]; [1]*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 Core Multiplicity Factor, Yuto Sagae[1], Takashi Matsui[1], Taiji Sakamoto[1], Taro Iwaya[1], Takayoshi Mori[1], Takanori Sato[2], Kunimasa Saitoh[2], Kazuhide Nakajima[1]; [1]*NTT Corporation, Japan;* [2]*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 µm^2 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 Kremp[1], Yue Liang[2], Alan H. McCurdy[2]; [1]*OFS Laboratories, OFS Fitel, LLC, USA;* [2]*OFS Fitel 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.

Singapore

13:30–15:15
Tu3B • Security
Presider: Reza Nejabati; Univ. of Bristol, UK

Tu3B.1 • 13:30 Invited
Physical Layer Security Management in Optical Networks, Marija Furdek[1], Carlos Natalino[1]; [1]*Chalmers Tekniska Högskola, Sweden*. As critical communication infrastructure, optical networks must operate 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 ★ Highly Scored
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 Arabul[1], Romerson Oliveira[1], Rui Wang[1], Obada Alia[1], George Kanellos[1], Reza Nejabati[1], Dimitra Simeonidou[1]; [1]*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 Copropagating Quantum and Classical Bits for Quantum Wrapper Networking, Sandeep Kumar Singh[1], Mehmet Berkay On[1], Roberto Proietti[3], Gregory S. Kanter[2], Prem Kumar[2], S. J. Ben Yoo[1]; [1]*Univ. of California Davis, USA;* [2]*Northwestern Univ., USA;* [3]*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 < 5E-7 for the classical bits.

Sydney

13:30–15:15
Tu3C • High Performance Computer Networks and High Throughput Transceivers
Presider: Nikos Pleros; Aristoteleio Panepistimio Thessalonikis, Greece

Tu3C.1 • 13:30 Invited
Peta-Scale Embedded Photonics for High Performance Computing, Keren Bergman[1]; [1]*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-picojoule/bit. We demonstrate how such photonic connectivity in disaggregated architectures accelerates distributed ML applications.

Tu3C.2 • 14:00 Invited
Datacenter Optical Transceivers in the Next Decade, Christopher R. Cole[1]; [1]*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.

Rio

13:30–14:45
Tu3D • Sensing and Nonlinearity Tolerant Schemes
Presider: Magnus Karlsson; Chalmers Tekniska Högskola, Sweden

Tu3D.1 • 13:30 Invited
Use of Optical Coherent Detection for Environmental Monitoring, Antonio Mecozzi[2], Cristian Antonelli[2], Mikael Mazur[1], Nicolas K. Fontaine[1], Haoshuo Chen[1], Lauren Dallachiesa[1], Roland Ryf[1]; [1]*Nokia Bell Labs, USA;* [2]*Department of Physical and Chemical Sciences, Universita 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 Tasbihi[1], Frank R. Kschischang[1]; [1]*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 Askari[2], Lutz Lampe[2], Jeebak Mitra[1]; [1]*Huawei Technologies Canada, Canada;* [2]*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.

Boston

13:30–15:15
Tu3E • Lasers for Silicon Photonics and Sensing
Presider: Shinji Matsuo; NTT Device Technology Labs, Japan

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[1]; [1]*SCINTIL Photonics, France.* Abstract not available.

Tu3E.2 • 14:00
High Power, Circular Beam CW DFB Laser Using BEX Layer, Shoko Yokokawa[1], Atsushi Nakamura[1], Shigetaka Hamada[1], Ryosuke Nakajima[1], Ryu Washino[1], Kaoru Okamoto[1], Masatoshi Arasawa[1], Kouji Nakahara[1], Shigehisa Tanaka[1]; [1]*Lumentum Japan, Inc., Japan.* High output power CW DFB laser with 18°x18° FFP is experimentally demonstrated. BEX layer that contributes to circular beam was introduced. The optimal combination of BEX layer with the mesa width was investigated by simulation, resulting in coupling efficiency to increase 3 dB.

Tu3E.3 • 14:15
300-m Multimode Fiber Transmission of 106Gbps PAM-4 Using 850nm High-Contrast-Grating Few-Mode VCSELs, Jiaxing Wang[1], Yipeng Ji[1], Zhuokai Yang[1], Huawen Hu[1], Jianqiang Chen[1], Haolin Li[1], Fangzhou Li[1], Shasha Li[1], Jonas Kapraun[1], Chih-Chiang Shen[1], Constance Chang-Hasnain; [1]*Shenzhen Berxel Photonics Co., Ltd., China.* 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.

Shanghai

13:30–15:00
Tu3F • Satellite Based Optical Freespace Communication I
Presider: Peter Ossieur; Ghent Univ., INTEC, Belgium

Tu3F.1 • 13:30 Invited
New Generation Space Photonic Components and Sub-Systems for High Data Rate Intra and Inter-Satellite Optical Communications, Leontios Stampoulidis[1]; [1]*G&H, Greece.* Abstract not available.

Tu3F.2 • 14:00
Block Interleaver Dimensioning and Real-Time Demonstration for Ground-to-Satellite Optical Communications, Daniel Romero[1,2], Sylvain Almonacil[1], Jean-Marc Conan[2], Laurie Paillier[2], Vincent Michau[2], Eric Dutisseuil[1], Sebastien Bigo[1], Jeremie Renaudier[1], Rajiv Boddeda[1]; [1]*Nokia Bell Labs, Route de Villejust, 91620 Nozay, France, France;* [2]*ONERA, DOTA, Paris Saclay Univ., F-92322 Châtillon, France.* We provide 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[1], Shota Ishimura[1], Kosuke Nishimura[1], Takehiro Tsuritani[1]; [1]*KDDI Research, Inc., Japan.* 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-OWL are improved by 20% and 18%, respectively.

Kairo

13:30–15:15
Tu3G • Novel Photonic Platforms and Sources II
Presider: Anna Fontcuberta I Morral; Ecole Polytechnique Federale de Lausanne, Switzerland

Tu3G.1 • 13:30 Invited
EUV Lithography: A Role in Photonics? A Deeper Insight in the EUV Exposure Tools, Jan van Schoot[1]; [1]*ASML Netherlands B.V., Netherlands.* In IC manufacturing 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 Tutorial
The State of the Art and Challenges of Silicon Photonics Today, Michal Lipson[1]; [1]*Columbia Univ., USA.* 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.

Delhi

13:30–15:15
Tu3H • IEEE International Network Generations Optics Roadmap, 1st Edition
Organisers: Dan Kilper; Trinity College Dublin, Ireland
Shan Wey, Verizon, USA

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.

Samarkand + Osaka

Tu3A • Fiber for High Capacity Transmission—Continued

Tu3A.4 • 14:30
Experimental Investigation of Coupling Offset Tolerances in a Space-Division Multiplexed 15-Mode Fiber Transmission System, Georg Rademacher[1], Ruben S. Luis[1], Benjamin J. Puttnam[1], Nicolas K. Fontaine[2], Mikael Mazur[2], Haoshuo Chen[2], Roland Ryf[2], David T. Neilson[2], Pierre Sillard[3], Frank Achten[4], Yoshinari Awaji[1], Hideaki Furukawa[1]; *[1]National Inst of Information & Comm Tech, Japan; [2]Nokia Bell Labs, USA; [3]Prysmian Group, France; [4]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 Invited
Commercial Opportunities and Future Roadmap for Hollow Core Fibres, Russell Ellis[1], M. Fake[1], A. Saljoghei[1], S.R. Sandoghchi[1], Hesham Sakr[2], Thomas Bradley[2], J. Hayes[2], Gregory Jasion[2], E. Numkam Fokoua[2], David Richardson[2], Francesco Poletti[2]; *[1]Lumenisity Ltd., UK; [2]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.

Singapore

Tu3B • Security—Continued

Tu3B.4 • 14:30
An Experimental Demonstration of Secure OFDM-PONs Using Multi-Band Chaotic Non-Orthogonal Matrix-Based Encryption, Peiji Song[1], Zhouyi Hu[2], Chun-Kit Chan[3]; *[1]Department of Information Engineering, The Chinese Univ. of Hong Kong, Hong Kong; [2]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^{768}, 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, Moisés Felipe[1], Alessandro Pacini[2], Andrea Sgambelluri[2], Francesco Paolucci[3], Luca Valcarenghi[2]; *[1]Los Alamos National Laboratory, USA; [2]TeCIP Inst., Scuola Superiore Sant'Anna, Italy; [3]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[2], Fransisco Martinez Rodriguez[2], Stefano Straullu[3], Emanuele E. Virgillito[1], Andrea Castoldi[2], Andrea D'Amico[1], Francesco Aquilino[3], Rosanna Pastorelli[2], Vittorio Curri[1]; *[1]Politecnico di Torino, Italy; [2]SM-Optics, Italy; [3]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.

Sydney

Tu3C • High Performance Computer Networks and High Throughput Transceivers—Continued

Tu3C.3 • 14:30
Nonlinear Pre-Distortion Through a Multi-Rate End-to-end Learning Approach Over VCSEL-MMF IM-DD Optical Links, Leonardo Minelli[1], Fabrizio Forghieri[2], Roberto Gaudino[1]; *[1]Politecnico di Torino, Italy; [2]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 ★ Highly Scored
800Gb/s PAM4 Transmission Over 10km SSMF Enabled by Low-Complex Duobinary Neural Network Equalization, Christian Blümm[1], Bo Liu[2], Bing Li[2], Talha Rahman[1], Md Sabbir-Bin Hossain[1], Maximilian Schaedler[1], Ulf Schlichtmann[2], Maxim Kuschnerov[1], Stefano Calabrò[1]; *[1]Huawei Technologies, Germany; [2]Chair for Electronic Design Automation, Technical Univ. Munich, Germany.* On 10km 200Gb/s 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[1], Christopher Parsonson[1], Zacharaya Shabka[1], Xun Mu[1], Alessandro Ottino[1], Georgios Zervas[1]; *[1]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.

Rio

Tu3D • Sensing and Nonlinearity Tolerant Schemes—Continued

Tu3D.4 • 14:30
Precise Characterization of Nonlinear Distortion in IM-DD System with Nonnegligible Chromatic Dispersion, Jingnan Li[1], Xiaofei Su[1], Tong Ye[1], Zhenning Tao[1], Hisao Nakashima[2], Takeshi Hoshida[2]; *[1]Fujitsu R&D Center, China; [2]Fujitsu Ltd., Japan.* We experimentally verify that the noise-to-power ratio method precisely characterizes nonlinear distortion caused by the interaction among modulation, chromatic dispersion, and detection in the DFB laser-based IM-DD transmission system. The equivalent additive noise model estimates the system performance with the accuracy of 0.5 dB.

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

Boston

Tu3E • Lasers for Silicon Photonics and Sensing—Continued

Tu3E.4 • 14:30
Lithium-Niobate-Based Frequency-Agile Integrated Lasers, Viacheslav Snigirev[1], Annina Riedhauser[3], Grigorii Likhachev[1], Johann Riemensberger[1], Rui N. Wang[1], Charles Möhl[3], Mikhail Churaev[1], Anat Siddhart[1], Guanhao Huang[1], Youri Popoff[3,2], Ute Drechsler[3], Daniele Caimi[3], Simon Hönl[3], Junqiu Liu[1], Paul Seidler[3], Tobias Kippenberg[1]; *[1]EPFL, Switzerland; [2]Eidgenossische Technische Hochschule Zurich, Switzerland; [3]IBM 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 > 10 peta-Hertz-per-second. We also perform FMCW LiDAR ranging experiments.

Tu3E.5 • 14:45
Beam-Curvature-Compensated Solid-State Beam Scanner Integrated with Multi-Grating Pitch Tunable Slow-Light VCSELs for Enhanced Field of View, Ruixiao Li[1], Xiaodong Gu[1,2], Satoshi Shinada[3], Fumio Koyama[1]; *[1]Tokyo Kogyo Daigaku - Suzukakedai Gakuen, Japan; [2]Ambition Photonics Inc., Japan; [3]Kokuritsu Kenkyu Kaihatsu Hojin Joho Tsushin Kenkyu Kiko, Japan.* We realized 1D solid-state VCSEL beam scanner with field of view (FOV) of >24°x15° integrating tunable VCSELs of different surface grating pitches. We also compensated the curvature of output fan beam by introducing curved prism mirror. The FOV was expanded to >64°x14° with DOE.

Tu3E.6 • 15:00
Few-Modes Locking in a Photonic Bandgap III-v on Silicon Laser, Pierre Fanneau de La Horie[1], Théo Verolet[2], Delphine Neel[1], Alexandre Shen[1], Jean-Guy Provost[1], Stephane Malhouitre[3], Valentin Ramez[3], Karim Hassan[3], Jean Decobert[1], Joan Ramirez[1], Alfredo de Rossi[4], David Bitauld[1]; *[1]III-V Lab, France; [2]Nokia, USA; [3]Commissariat a l'energie atomique et aux energies alternatives Laboratoire d'electronique et de technologies de l'information, France; [4]Thales SA, France.* We demonstrate stable operation of a multimode DFB laser based on a 1D photonic crystal cavity. The laser signal comprises three modes spaced by ~28 GHz with linewidths below 135 kHz. Under mode-locking operation, the laser beat tone is narrowed down to 20 kHz.

Shanghai

Tu3F • Satellite Based Optical Freespace Communication I—Continued

Tu3F.4 • 14:30
On the Mitigation of Doppler Shift for High-Capacity Coherent FSO Satellite-to-Earth Links, Marco A. Fernandes[1], Paulo P. Monteiro[1], Fernando Guiomar[1]; *[1]Instituto de Telecomunicações de Aveiro, Portugal.* We experimentally assess the impact of the Doppler shift 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.

Tu3F.5 • 14:45
Towards Fully Integrated Longwave Infrared Heterodyne Detector Based on Quantum Cascade Technology, Mauro David[1], Georg Marschick[1], Elena Arigliani[1], Nikola Opacak[1], Benedikt Schwarz[1], Gottfried Strasser[1], Borislav Hinkov[1]; *[1]TU 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.

Kairo

Tu3G • Novel Photonic Platforms and Sources II—Continued

Tu3G.3 • 15:00
Real-Time Transition Dynamics of Harmonically Mode-Locked Femtosecond Ultralong Ring Fiber Lasers, Inés Cáceres Pablo[1,2], Juan Diego Ania Castañón[1,2]; *[1]Instituto de Optica Daza de Valdes, Spain; [2]Consejo Superior de Investigaciones Cientificas, Spain.* The transition dynamics between harmonic mode-locking states in Raman-assisted ultralong ring fiber lasers assisted 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.

Delhi

Tu3H • IEEE International Network Generations Optics Roadmap, 1st Edition—Continued

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

Samarkand + Osaka

15:45–17:45
Tu4A • Fiber Sensing and Characterization
Presider: Luc Thevenaz; Ecole Polytechnique Federale de Lausanne, Switzerland

Tu4A.1 • 15:45 Invited
Time-Expansion in Distributed Fibre Optic Sensing, Miguel Gonzalez-Herraez[1], Miguel Soriano-Amat[1], Vicente Duran[2], Hugo F. Martins[3], Sonia Martin-Lopez[1], Maria R. Fernandez-Ruiz[1]; *[1]Universidad de Alcala, Spain; [2]Universitat Jaume I, Spain; [3]Consejo Superior de Investigaciones Cientificas, 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).

Tu4A.2 • 16:15
Improving Earthquake Detection in Fibre-Optic Distributed Acoustic Sensors Using Deep-Learning and Hybrid Datasets, Pablo D. Hernández[1], Jaime A. Ramírez[2], Marcelo A. Soto[1]; *[1]Universidad Técnica Federico Santa María, Chile; [2]Novelcode 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.

Singapore

15:45–19:00
Tu4B • Recent Advances in Submarine Systems
Organisers: Hidenori Takahashi, KDDI Researh, Inc., Japan
Lara Garrett, SubCom, USA

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.

Sydney

15:45–17:15
Tu4C • High-Speed PON Technologies
Presider: Paulo Monteiro; IT /UA, Portugal

Tu4C.1 • 15:45 Invited
Digital Signal Processing for Next Generation PONs, Amitkumar Mahadevan[1]; *[1]Nokia 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 Houtsma[1], Dora V. Veen[1]; *[1]Nokia 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.

Rio

15:45–17:15
Tu4D • Free-Space and Quantum Communication
Presider: Helmut Griesser; ADVA Optical Networking, Germany

Tu4D.1 • 15:45 Tutorial
Modal Multiplexing and Atmospheric Turbulence Mitigation in Free-Space Optical Communications, Joseph M. Kahn[1], Aniceto Belmonte[2]; *[1]Stanford Univ., USA; [2]Technical 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 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.

Boston

15:45–17:30
Tu4E • Advanced Modulators
Presider: Mitsuru Takenaka; Univ. of Tokyo, Japan

Tu4E.1 • 15:45
High-Bandwidth Lithium Niobate Electro-Optic Modulator at Visible-Near-Infrared Wavelengths, David Pohl[1], Jost Kellner[1], Fabian Kaufmann[1], Alfonso Martínez-García[1,2], Giovanni Finco[1], Andreas Maeder[1], Marc Reig-Escalé[1,2], Rachel Grange[1]; *[1]ETH Zurich, Switzerland; [2]Versics AG, Switzerland.* Lithium niobate on insulator is presented as a platform for active integrated photonics at visible-near-infrared wavelengths. An electro-optic modulator operating at 780 nm featuring an electrical 3-dB bandwidth of 35 GHz and a halfwave voltage of 2.82 V is demonstrated, enabling transmission of a 40 Gbit/s on-off keying signal.

Tu4E.2 • 16:00
Low-Loss Ti-Diffused $LiNbO_3$ Modulator Integrated with Electro-Optic Frequency-Domain Equalizer for High Bandwidth Exceeding 110 GHz, Yuya Yamaguchi[1], Pham Tien Dat[1], Shingo Takano[2], Masayuki Motoya[2], Yu Kataoka[2], Junichiro Ichikawa[2], Satoshi Oikawa[2], Ryo Shimizu[2], Naokatsu Yamamoto[1], Atsushi Kanno[1], Tetsuya Kawanishi[3,1]; *[1]NICT, Japan; [2]Sumitomo Osaka Cement, Japan; [3]Waseda Univ., Japan.* We propose and demonstrate a low-loss and high-bandwidth lithium niobate modulator integrated with an electro-optic frequency-domain equalizer. The fabricated Ti-diffused lithium niobate modulator has a low optical loss of 5.4 dB, low half-wave voltage of 3.7 V, and high bandwidth exceeding 110 GHz.

Tu4E.3 • 16:15 Invited
Plasmonic PICs: Terabit Modulation on the Micrometer Scale, Wolfgang Heni[1], Patrick Habegger[1,2], Eva De Leo[1], Marcel Destraz[1], Norbert Meier[1], Nino Del Medico[1], Valentino Tedaldi[1], Christian Funck[1], Adrian Langenbach[1], Hamit Duran[1], Nicholas Guesken[1], Juerg Leuthold[2,1], Claudia Hoessbacher[1], Benedikt Baeuerle[1]; *[1]Polariton Technologies Ltd, Switzerland; [2]Inst. of Electromagnetic Fields (IEF), Eidgenossische Technische Hochschule Zurich, Switzerland.* Plasmonic PICs offer compact high-speed photonic and plasmonic components, enabling a new generation of scalable photonic system solutions. We explain the underlying technology, highlight key applications, review technology demonstrations, and discuss future opportunities.

Shanghai

15:45–17:15
Tu4F • FSO Communication
Presider: Mathilde Gay; ENSSAT, France

Tu4F.1 • 15:45
Bi-Directional All-Optical Wireless Communication System with Optical Beam Steering and Automatic Self-Alignment, Ton Koonen[1], Ketema A. Mekonnen[1], Frans M. Huijskens[1], Eduward Tangdiongga[1]; *[1]Technische Universiteit Eindhoven, Netherlands.* A Gigabit Ethernet bidirectional OWC system with user-hosted automatic alignment of the upstream beams is demonstrated, using miniature retroreflectors and novel self-alignment algorithm. It provides individual narrow beams for high user densities. TCP measurements show transfer speeds of 940Mbit/s per user within 10 degrees Field-of-View.

Tu4F.2 • 16:00
All-Optical Mobile FSO Transceiver with High-Speed Laser Beam Steering and Tracking, Abdelmoula Bekkali[1], Fujita Hideo[1], Michikazu Hattori[1], Yuichiro Hara[1], Toshimasa Umezawa[2], Atsushi Kanno[2]; *[1]TOYO Electric Corpration, Japan; [2]National Inst. of Information and Communications Technology (NICT), Japan.* We introduce an all-optical FSO system for moving platforms, by combining fast-steering-mirrors and optical-beam-stabilizer technologies for laser beam steering, tracking and seamless coupling to the SMF. Error-free transmission and mask compliance of 10GbE signal were achieved with 5 deg/sec horizontal mobility and 5 degrees FOV.

Tu4F.3 • 16:15 Invited
Latest Developments in the Field of Optical Communications for Small Satellites and Beyond, Dimitar R. Kolev[1], Morio Toyoshima[1]; *[1]National Inst of Information & Comm Tech, Japan.* This paper introduces the latest trends in the field of space optical communications for small satellites including the National Inst. of Information and Communications Technology (NICT) efforts to develop payloads for small moving platforms and the HICALI project for an optical feederlink between a Geostationary Earth Orbit Satellite and ground.

Kairo

15:45–17:15
Tu4G • Photonic Neural Networks
Presider: Folkert Horst; International Business Machines Corp, Switzerland

Tu4G.1 • 15:45 Invited
Silicon Photonics for Machine Learning: Training and Inference, Bhavin J. Shastri[1], Matthew Filipovich[1], Zhimu Guo[1], Paul Prucnal[2], Alexander Tait[1], Chaoran Huang[5], Sudip Shekhar[3], Volker J. Sorger[4]; *[1]Queen's Univ., Canada; [2]Princeton Univ., USA; [3]The Univ. of British Columbia, Canada; [4]Georgetown Univ., USA; [5]The Chinese Univ. of Hong Kong, Hong Kong.* Photonics neural networks employ optical device physics for neuron models, and optical interconnects for distributed, parallel, and analog processing for high-bandwidth, low-latency, and low-switching energy applications in AI and neuromorphic computing. We discuss silicon photonics for machine learning acceleration for inference and in situ training.

Tu4G.2 • 16:15
SOA-Based All-Optical Photonic Integrated Deep Neural Network with Stable Output Noise, Bin Shi[1], Nicola Calabretta[1], Ripalta Stabile[1]; *[1]Technische Universiteit Eindhoven, Netherlands.* 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 noise compression.

Delhi

16:30–18:30
13th European Photonic Integration Forum
Organisers: ePIXfab JePPIX

See page 116 of this programme for more information about this Forum.

Samarkand + Osaka

Tu4A • Fiber Sensing and Characterization—Continued

Tu4A.3 • 16:30
Distributed Measurement of Rayleigh Backscattered Crosstalk for Bidirectional Multicore Fiber Transmissions Using Multi-Channel Optical Time Domain Reflectometr, Yuto Kobayashi[1], Tetsuya Hayashi[1], Takemi Hasegawa[1], Takahiro Suganuma[1], Ayumi Inoue[1], Takuji Nagashima[1], Hirotaka Sakuma[1], Takahiro Kikuchi[1], Osamu Shimakawa[1], Hidehisa Tazawa[1], Masato Yoshida[2], Masataka Nakazawa[2]; [1]*Optical Communications Laboratory, Sumitomo Electric Industries Ltd, Japan;* [2]*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[1], Masaki Ohzeki[1], Katsuhiro Takenaga[1], Kentaro Ichii[1]; [1]*Kabushiki Kaisha Fujikura 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.

Singapore

Tu4B • Recent Advances in Submarine Systems—Continued

Sydney

Tu4C • High-Speed PON Technologies—Continued

Tu4C.3 • 16:30
Real-Time 100Gb/s Downstream PAM4 PON Link With 34 dB Power Budget, Giuseppe Caruso[1,2], Ivan N. Cano[1], Derek Nesset[1], Giuseppe Talli[1], Roberto Gaudino[2]; [1]*Munich Research Centre, Huawei Technologies, Germany;* [2]*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.

Tu4C.4 • 16:45
Cross Gain Modulation Mitigation with Automatic Gain Control of Bidirectional SOA for DSP-Free 50G-PON, Jeremy Potet[1,2], Gael Simon[1], Fabienne Saliou[1], Philippe Chanclou[1], Mathilde Gay[2], Laurent Bramerie[2], Monique Thual[2], Hélène Debregeas[3], Elena Duran[3], Natalia Dubrovina[3]; [1]*Orange, France;* [2]*Fonctions Optiques pour les Technologies de l'information, France;* [3]*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.

Rio

Tu4D • Free-Space and Quantum Communication—Continued

Tu4D.2 • 16:45 Invited
High Secret Key Rate CV-QKD Systems Leveraged by Advanced Coherent Detection, Amirhossein Ghazisaeidi[1]; [1]*Nokia Bell Labs France, France.* We review the fundamentals of the continous-variable quantum key distribution, covering concepts from information theory, quantum optics and cryptography, and then discuss the recent efforts to implement those protocols using optical coherent detection technology.

Tu4E • Advanced Modulators—Continued

Tu4E.4 • 16:45
Is There an Ideal Plasmonic Modulator Configuration?, Tobias Blatter[1], Yannik Horst[1], Wolfgang Heni[2], Christos Pappas[4], Apostolos Tsakyridis[4], George Giamougiannis[4], Marco Eppenberger[1], Manuel Kohli[1], Ueli Koch[1], Miltiadis Moralis-Pegios[4], Nikos Pleros[3], Juerg Leuthold[1]; [1]*ETH Zurich, Switzerland;* [2]*Polariton Technologies AG, Switzerland;* [3]*Aristoteleio Panepistemio Thessalonikes Polytechnike Schole, Greece;* [4]*Aristotle 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 $0.5V_p$.

Tu4F • FSO Communication—Continued

Tu4F.4 • 16:45 ★ Highly Scored
Demonstration of Turbulence-Resilient Self-Homodyne 12-Gbit/s 16-QAM Free-Space Optical Communications Using a Transmitted Pilot Tone, Huibin Zhou[4], Runzhou Zhang[4], Xinzhou Su[4], Yuxiang Duan[4], Haoqian Song[4], Hao Song[4], Kaiheng Zou[4], Robert Boyd[3,2], Moshe Tur[1], Alan Willner[4]; [1]*Tel Aviv Univ., Israel;* [2]*Univ. of Rochester, USA;* [3]*Univ. of Ottawa, Canada;* [4]*Univ. 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 • Photonic Neural Networks—Continued

Tu4G.3 • 16:30
Photonic Reservoir Computing for Nonlinear Equalization of 64-QAM Signals with a Kramers-Kronig Receiver, Sarah Masaad[1], Emmanuel Gooskens[1], Stijn Sackesyn[1], Joni Dambre[1], Peter Bienstman[1]; [1]*Ghent 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.

Tu4G.4 • 16:45 Invited
WDM Based Photonic Neural Network for Multi-Channel Optical Fiber Communications, Chaoran Huang[1]; [1]*Chinese Univ. of Hong Kong, Hong Kong.* Abstract not available.

13th European Photonic Integration Forum—Continued

Samarkand + Osaka

Tu4A • Fiber Sensing and Characterization—Continued

Tu4A.5 • 17:00
Measurement of Mode-Coupling Along a Multi-Core Submarine Fiber Cable with a Multi-Channel OTDR, Masato Yoshida[1], Toshihiko Hirooka[1], Masataka Nakazawa[1], Tetsuya Hayashi[2], Takemi Hasegawa[2], Kohei Nakamura[3], Takanori Inoue[3]; *[1]Tohoku Univ., Japan; [2]Sumitomo Electric Industries, Ltd., Japan; [3]NEC 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 Fibre by Changing Core and Cladding Gas Pressures, Natalie V. Wheeler[1], Thomas Kelly[1], Ian A. Davidson[1], Shuichiro Rikimi[1], Gregory Jasion[1], Austin Taranta[1], David Richardson[1], Francesco Poletti[1], Peter Horak[1]; *[1]Univ. 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.

Singapore

Tu4B • Recent Advances in Submarine Systems—Continued

Sydney

Tu4C • High-Speed PON Technologies—Continued

Tu4C.5 • 17:00
SOA Pre-Amplified 200 Gb/s/λ PON Using High-Bandwidth TFLN Modulator, Jie Li[1], Xu Zhang[1], Ming Luo[1], Chao Yang[1], Zhixue He[1], Xi Xiao[1]; *[1]State 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.

Rio

Tu4D • Free-Space and Quantum Communication—Continued

17:30–19:00 Tu5 • Joint Poster Session I, *Foyer 2nd Floor*

17:30–19:00
Lab Automation Hackathon
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

See page 116 of this programme for more information about this event.

19:30–23:00 Gala Dinner, *MS Rhystärn, Schifflände Basel, 4051 Basel*

Boston

Tu4E • Advanced Modulators—Continued

Tu4E.5 • 17:00
216 GBd Plasmonic Ferroelectric Modulator Monolithically Integrated on Silicon Nitride, Manuel Kohli[1], Daniel Chelladurai[1], Andreas Messner[1], Yannik Horst[1], David Moor[1], Joel Winiger[1], Tobias Blatter[1], Tatiana Burikova[2], Clarissa Convertino[3], Felix Eltes[3], Michael Zervas[2], Yuriy Fedoryshyn[1], Ueli Koch[1], Juerg Leuthold[1]; [1]*Inst. of Electromagnetic Fields (IEF), Eidgenossische Technische Hochschule Zurich, Switzerland;* [2]*Ligentec SA, Switzerland;* [3]*Lumiphase 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 Gupta[1], Guillaume Binet[1], Wouter Diels[1], Jo Alexander Heibach[1], Jonathan Hogan[1], Moritz Baier[1], Martin Schell[1]; [1]*Fraunhofer Heinrich Hertz Inst., Germany.* High-speed (80 Gbps), low drive-voltage ($V_\pi L$ = 0.9 V-cm), low insertion loss (IL = 11 dB) travelling wave electrodes based Mach-Zehnder modulators are presented on an open-access InP platform.

Shanghai

Tu4F • FSO Communication—Continued

Tu4F.5 • 17:00 ★ Highly Scored
Single-Wavelength Terabit Multi-Modal Free Space Optical Transmission with Commercial Transponder, Zhouyi Hu[1], Yiming Li[1], David Benton[1], Abdallah Ali[1], Mohammed Patel[1], Andrew Ellis[1]; [1]*Aston Univ., UK.* We demonstrate a record-high net single-wavelength data rate of 1.1 Tbit/s and spectral efficiency of 28.35 bit/s/Hz over a multi-modal free space optical link with fully independent channels and all key devices used in this work commercially available.

Kairo

Tu4G • Photonic Neural Networks—Continued

Delhi

13th European Photonic Integration Forum—Continued

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*

08:00–17:30 Registration, *Entrance Hall 1*

08:30–10:00
We1A • Ultra-wideband Optical Systems
Presider: Andrea Carena; Politecnico di Torino, Italy

We1A.1 • 08:30 Invited

Challenges in Modeling Wideband Transmission Systems, Andre Richter[1], Gabriele di Rosa[1], Igor Koltchanov[1]; [1]*VPIphotonics, 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.

08:30–10:00
We1B • Network Planning and Cost Efficiency
Presider: Yvan Pointurier; Huawei, France

We1B.1 • 08:30

Comparison of Single-Wavelength and Multi-Wavelength Transponders in a Physical-Layer-Aware Network Planning Study, Jasper Müller[3,1], Ognjen Jovanovic[2,3], Carmen Mas-Machuca[1], Helmut Griesser[3], Tobias Fehenberger[3], Jörg-Peter Elbers[3]; [1]*Chair of Communication Networks, Technische Universitat Munchen, Germany;* [2]*DTU Electro, Danmarks Tekniske Universitet, Denmark;* [3]*ADVA 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.

We1B.2 • 08:45

Extending the C+L System Bandwidth Versus Exploiting Part of the S-Band: Network Capacity and Interface Count Comparison, Raoul Sadeghi Yamchi[1], Bruno Correia[1], Nelson Costa[2], João Pedro[2], Antonio Napoli[3], Vittorio Curri[1]; [1]*Politecnico di Torino, Italy;* [2]*Infinera Corp, Portugal;* [3]*Infinera Corp, Germany.* In this work, the network capacity and device count (amplifiers and interfaces) are investigated for different multi-band approaches, highlighting the trade-off between exploiting part of the S-band and extending C+L-band systems.

08:30–10:15
We1C • Digital Optical Fiber Nonlinearity Mitigation
Presider: Domanic Lavery; Infinera Corporation, UK

We1C.1 • 08:30 Invited

GAWBS Noise in Digital Coherent Transmission, Masataka Nakazawa[1]; [1]*Tohoku 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.

08:30–10:15
We1D • Subsea Communications
Presider: Alexei Pilipetskii; SubCom LLC, USA

We1D.1 • 08:30 Tutorial

Subsea Open Cables Designs, Challenges and an Outlook for the Future, Elizabeth Rivera Hartling[1]; [1]*Meta 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.

08:00–17:30 Registration, *Entrance Hall 1*

08:30–10:15
We1E • Heterogeneous Integration
Presider: Jon Heffernan; Univ. of Sheffield, UK

We1E.1 • 08:30 Invited

Hybrid Integration of GaSb Optoelectronics with Thick-SOI and SiN PIC Platforms, Mircea D. Guina[1], Samu-Pekka Ojanen[1], Nouman Zia[1], Heidi Tuorila[1], Joonas Hilska[1], Eero Koivusalo[1], Jukka Viheriälä[1]; *[1]Tampere Univ., Finland.* Recent advances in developing light sources based on hybrid integration of 2–3 µm GaSb gain blocks with silicon-on-insulator and SiN passive circuits are discussed. We address new development trends requiring PICs operating above 2 µm wavelength for applications in environmental sensing and health monitoring.

08:30–10:15
We1F • MW Photonics and Lidar
Presider: Liam Barry; Dublin City Univ., Ireland

We1F.1 • 08:30

Microwave Photonic RF Comb Generator up to 140 GHz, Hendrik Boerma[1], Felix Ganzer[1], Patrick Runge[1], Martin Schell[1,2], Edgar Fernandes[3], Benjamin Rudin[3], Florian Emaury[3]; *[1]Fraunhofer Heinrich-Hertz-Inst., Germany; [2]Technical Univ. Berlin, Germany; [3]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.

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 Tanaka[1], Shinji Nimura[1], Shota Ishimura[1], Kosuke Nishimura[1], Ryo Inohara[1], Takehiro Tsuritani[1], Masatoshi Suzuki[1]; *[1]KDDI Research, Inc., Japan.* 4608 × 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.

08:30–10:15
We1G • Nonlinear Optics in $\chi^{(2)}/\chi^{(3)}$ Integrated Photonics
Organiser: Camille-Sophie Brès, EPFL, Switzerland

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 focusses 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.

08:30–10:15
We1H • 8th International Symposium for Optical Interconnect in Data Centres I
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, 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.

Samarkand + Osaka

We1A • Ultra-wideband Optical Systems—Continued

We1A.2 • 09:00
Closed-Form Expressions for the Impact of Stimulated Raman Scattering Beyond 15 THz, Dimitris Uzunidis[1], Kostas Nikolaou[1], Chris Matrakidis[1], Alexandros Stavdas[1], Andrew Lord[2]; *[1]OpenLightComm Europe, Czechia; [2]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.

We1A.3 • 09:15
Link and Network-Wide Study of Incoherent GN/EGN Models, Farhad Arpanaei[1], Mehdi Ranjbar[2], José Alberto Hernández[1], Andrea Carena[3], David Larrabeiti[1]; *[1]Univ. Carlos III of Madrid, Spain; [2]Cisco Systems Inc, Italy; [3]Politecnico di Torino, Italy.* An unprecedented comparison of closed-form incoherent GN (InGN) models is presented with heterogeneous spans and partially loaded links in elastic optical networks. Results reveal that with accumulated dispersion correction and modulation format terms, the InGN shows higher accuracy.

We1A.4 • 09:30 ★ Highly Scored
Spectral Power Profile Optimization of Field-Deployed WDM Network by Remote Link Modeling, Rasmus T. Jones[2], Kyle Bottrill[1], Natsupa Taengnoi[1], Periklis Petropoulos[1], Metodi P. Yankov[2]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK; [2]DTU Fotonik, Danmarks Tekniske Universitet, Denmark.* A digital twin model of a multi-node WDM network is obtained from a single access point. The model is used to predict and optimize the transmit power profile for each link in the network and up to 2.2 dB of margin improvements are obtained w.r.t. unoptimized transmission.

Singapore

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, Memedhe Ibrahimi[1], Giovanni Simone Sticca[1], Francesco Musumeci[1], Andrea Castoldi[2], Rosanna Pastorelli[2], Massimo Tornatore[1]; *[1]Politecnico di Milano, Italy; [2]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 compare eight strategies for amplifier deployment showing that an optimized placement of Raman amplification can lead to 40% fewer amplifiers compared to baseline deployment practices.

We1B.4 • 09:15
Experimental Optimization of Spectrum-Efficient Super-Channels in Elastic Optical Networks, Margita Radovic[1], Andrea Sgambelluri[1], Filippo Cugini[2], Nicola Sambo[1]; *[1]Scuola Superiore Sant'Anna, Italy; [2]Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Italy.* Automatic super-channel optimization is experimentally demonstrated using a 600Gb/s transponder in the SDN-controlled Elastic Optical Network. Margin reduction while guaranteeing Quality of Transmission allows for a spectrum occupation reduction of 25%.

We1B.5 • 09:30 Invited
Fiber- vs. Microwave-Based 5G Transport: A Total Cost of Ownership Analysis, Maryam Lashgari[1], Federico Tonini[1], Massimiliano Capacchione[2], Lena Wosinska[1], Gabriele Rigamonti[2], Paolo Monti[1]; *[1]Chalmers Tekniska Högskola, Sweden; [2]SIAE Microelettronica, Italy.* Answering a key question from operators, the paper compares the techno-economic performance of fiber and microwave-based 5G transport deployments using vendor's inventories and real-life field deployment scenarios. Results highlight how microwave gains vary based on the geo-types, the fiber trenching, and microwave equipment costs.

Sydney

We1C • Digital Optical Fiber Nonlinearity Mitigation—Continued

We1C.2 • 09:00 ★ Highly Scored
Towards FPGA Implementation of Neural Network-Based Nonlinearity Mitigation Equalizers in Coherent Optical Transmission Systems, Pedro Jorge J. Freire de Carvalho Souza[1,2], Michael Anderson[1], Bernhard Spinnler[2], Thomas Bex[2], Yaroslav Prylepskiy[1], Tobias Eriksson[2], Nelson Costa[2], Wolfgang Schairer[2], Michaela Blott[3], Antonio Napoli[2], Sergei Turistyn[1]; *[1]Aston Univ., UK; [2]Infinera Corp, Germany; [3]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.

We1C.3 • 09:15
Improving Nonlinearity Tolerance of PCS-QAM Digital Multi-Carrier Systems Through Symbol Rate Optimization, Abel Lorences-Riesgo[1], Manuel Neves[2], Celestino S. Martins[1], Sami Mumtaz[1], Pedro Loureiro[2], Yann Frignac[1], Paulo P. Monteiro[2], Gabriel Charlet[1], Fernando Guiomar[2], Stefanos Dris[1]; *[1]Huawei Technologies France SAS, France; [2]Instituto de Telecomunicacoes, Portugal.* We experimentally demonstrate that symbol-rate optimization provides nonlinear gains in multi-carrier systems, even with PCS modulation and realistic DSP. Optimized carrier phase recovery is crucial to achieving 0.2 dB gain for 1400 km 800G transmission, out of the ~0.7 dB theoretical maximum gain we measured.

We1C.4 • 09:30
Learning for Perturbation-Based Fiber Nonlinearity Compensation, Shenghang Luo[2], Sunish Kumar Orappanpara Soman[1], Lutz Lampe[2], Jeebak Mitra[3], Chuandong Li[3]; *[1]Ulster Univ., UK; [2]The Univ. of British Columbia, Canada; [3]Huawei Technologies Canada, Canada.* Several machine learning inspired methods for perturbation-based fiber nonlinearity (PB-NLC) compensation have been presented in recent literature. We critically revisit acclaimed benefits of those over non-learned methods. Numerical results suggest that learned linear processing of perturbation triplets of PB-NLC is preferable over feedforward neural-network solutions.

Rio

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 Carbo Meseguer[1], Joao L. De Oliveira Pacheco[1], Jean-Christophe Antona[1], Juliana Tiburcio de Araujo[1], Vincent Letellier[1]; *[1]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, Borislav Hinkov[1], Florian Pilat[1], Mauro David[1], Andreas Schwaighofer[1], Patricia L. Souza[2,1], Laurin Lux[1], Bettina Baumgartner[3,1], Daniela Ristanic[1], Benedikt Schwarz[1], Hermann Detz[1,4], Aaron M. Andrews[1], Bernhard Lendl[1], Gottfried Strasser[1]; *[1]TU Wien, Austria; [2]Lab-Sem-CETUC, Pontificia Universidade Catolica do Rio de Janeiro, Brazil; [3]Debye Inst. for Nanomaterials Science, Universiteit Utrecht, Netherlands; [4]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.

We1E.3 • 09:15 ★ Highly Scored
Uncooled 100-GBaud Operation of Directly Modulated Membrane Lasers on High-Thermal-Conductivity SiC Substrate, Suguru Yamaoka[1], Nikolaos P. Diamantopoulos[1], Hidetaka Nishi[1], Takuro Fujii[1], Koji Takeda[1], Tatsurou Hiraki[1], Shigeru Kanazawa[2], Takaaki Kakitsuka[1], Shinji Matsuo[1]; *[1]NTT Device Technology Labs, Japan; [2]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.

We1E.4 • 09:30
Micro-Transfer-Printed Membrane DR Lasers on Si Waveguide Modulated With 50-Gbit/s NRZ Signal, Yoshiho Maeda[1], Takuro Fujii[1], Takuma Aihara[1], Tatsurou Hiraki[1], Koji Takeda[1], Tai Tsuchizawa[1], Hiroki Sugiyama[1], Tomonari Sato[1], Toru Segawa[1], Yasutomo Ota[2,3], Satoshi Iwamoto[2,4], Yasuhiko Arakawa[2], Shinji Matsuo[1]; *[1]NTT Device Technology Labs, NTT Corporation, Japan; [2]Inst. for Nano Quantum Information Electronics, The Univ. of Tokyo, Japan; [3]Department of Applied Physics and Physico-Informatics, Keio Univ., Japan; [4]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.

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[2], Antonio D'Errico[3], Alessandra Bigongiari[3], Antonella Bogoni[1,2], Marco Secondini[1,2]; *[1]Scuola Superiore Sant'Anna, Italy; [2]Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Italy; [3]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.

We1F.4 • 09:15 Invited
State of the Art in Silicon Photonics Integrated Circuits for LIDAR, Jonathan Doylend[1]; *[1]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.

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

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

We1A • Ultra-wideband Optical Systems—Continued

We1A.5 • 09:45
Multifiber vs. Ultra-Wideband Upgrade: A Techno-Economic Comparison for Elastic Optical Backbone Network, Rana K. Jana[3], Md A. Iqbal[1], Neil Parkin[1], Anand Srivastava[3], Arvind Mishra[2], Jitendra Balakrishnan[2], Phillip Coppin[2], Andrew Lord[1], Abhijit Mitra[3,1]; *[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.

We1B • Network Planning and Cost Efficiency—Continued

We1C • Digital Optical Fiber Nonlinearity Mitigation—Continued

We1C.5 • 09:45
Deep Convolutional Recurrent Neural Network for Fiber Nonlinearity Compensation, Prasham Jain[1], Lutz Lampe[1], Jeebak Mitra[2]; *[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.

We1C.6 • 10:00
Learned Digital Back-Propagation for Dual-Polarization Dispersion Managed Systems, Mohannad Abu-Romoh[1], Nelson Costa[3], Antonio Napoli[2], Bernhard Spinnler[2], Yves Jaouen[1], Mansoor Yousefi[1]; *[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.

We1D • Subsea Communications—Continued

We1D.3 • 09:45 Invited
Strategies and Challenges in Designing Undersea Optical Links, Oleg V. Sinkin[1]; *[1]SubCom, USA.* We discuss trends and challenges in modern undersea optical fibre communications, which include power, space and cost efficiency. Progress in fibres and better subsystem engineering can address the problems in the near term. New technology discoveries are needed for efficient capacity scaling in the future.

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

We1E • Heterogeneous Integration—Continued

We1E.5 • 09:45 Invited

Photonic Neural Networks for Analog-Digital Processing, Thomas Ferreira de Lima[1]; [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 requires 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 • MW Photonics and Lidar—Continued

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 Schrenk[1]; [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[1], Feng Wang[1], Wen Zhou[1], Jianguo Yu[2], Feng Zhao[3], Jianjun Yu[1]; [1]*Fudan Univ., China;* [2]*(2) Beijing Univ. of Posts and Telecommunications, China;* [3]*(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.

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

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

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

Samarkand + Osaka

10:45–12:30
We2A • DCI and Metro Transmission Systems
Presider: Benedikt Baeuerle; Polariton Technologies Ltd, Switzerland

We2A.1 • 10:45
Amplifier-Free Low-CSPR Polarization-Division-Multiplexing Self-Homodyne Coherent Receiver for ZR Transmission, Ming-Ming Zhang[2], Yizhao Chen[1], Weihao Li[2], Junda Chen[2], Tianhao Tong[2], Zihe Hu[2], Yuqi Li[2], Jiajun Zhou[2], Zheng Yang[2], Ming Tang[2]; *[1]School of Cyber Science and Engineering, Huazhong Univ. of Science and Technology, China; [2]School 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 Repeatered Transmission with Bismuth-Doped Fibre Amplifiers, Yuta Wakayama[1], Daniel J. Elson[1], Vitaly Mikhailov[2], Rachata Maneekut[3], Jiawei Luo[2], Noboru Yoshikane[1], Daryl Inniss[2], Takehiro Tsuritani[1]; *[1]KDDI Research, Japan; [2]OFS Laboratories, USA; [3]Chulalongkorn 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.

Singapore

10:45–12:00
We2B • Control Plane and Automation
Presider: Marco Ruffini, Ireland

We2B.1 • 10:45 Invited
Unified SDN Control and Management of the Disaggregated Multi-Vendor IP Over Open Optical Network, Arturo Mayoral[1], Jean Francois Bouquier[2], José Antonio Gómez[2], Stefan Melin[4], Renzo Diaz[4], Oscar Gonzalez de dios[3], Juan-Pedro Fernández-Palacios[3], Kadir Coskun[5], Riza Bozaci[5], Steven Hill[6], Hanson Tuang[7]; *[1]Telecom Infra Project, USA; [2]Vodafone, Spain; [3]Telefónica I+D/Global CTO, Spain; [4]Telia Company, Sweden; [5]Turkcell, Turkey; [6]MTN, South Africa; [7]Meta 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.

Sydney

10:45–12:30
We2C • Deep Learning for Optical Fiber Communications
Presider: Francesco Da Ros; DTU Fotonik, Denmark

We2C.1 • 10:45 Tutorial
End-to-end Learning of Optical Communication Systems: A Beginner's Guide, Christian Häger[1]; *[1]Chalmers 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.

Rio

10:45–12:15
We2D • IM/DD & Short-Reach Communications
Presider: Norbert Hanik; Technische Universität Munchen, Germany

We2D.1 • 10:45 Invited
Advanced O-Band Transmission Using Maximum Likelihood Sequence Estimation, Hiroki Taniguchi[1], Shuto Yamamoto[1], Masanori Nakamura[1], Akira Masuda[1], Yoshiaki Kisaka[1], Shigeru Kanazawa[2], Hirotaka Nakamura[2]; *[1]NTT Network Innovation Laboratories, Japan; [2]NTT 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.

Boston

10:45–12:30
We2E • Programmable Photonics and Comb Lasers
Presider: Christian Koos, Germany

We2E.1 • 10:45
An Energy-Saving Optical Comb Generator by Deeply Driven MZM and Multi-Stage Phase Modulators, Tatsuki Ishijima[1], Shun Harada[1], Takahide Sakamoto[1]; [1]*Tokyo Metropolitan Univ., Japan.* 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. 37x25-GHz ultra-wideband combs are experimentally generated.

We2E.2 • 11:00
A Photonic Integrated Circuit-Based Erbium-Doped Waveguide Amplifier, Yang Liu[1,3], Zheru Qiu[1,3], Xinru Ji[1,3], Anton Lukashchuk[1,3], Jijun He[1,3], Johann Riemensberger[1,3], Martin Hafermann[2], Rui N. Wang[1,3], Junqiu Liu[1,3], Carsten Ronning[2], Tobias Kippenberg[1,3]; [1]*EPFL, Switzerland;* [2]*Inst. of Solid State Physics, Friedrich-Schiller-Universitat Jena, Germany;* [3]*Center for Quantum Science and Engineering, Ecole Polytechnique Federale de Lausanne, Switzerland.* We demonstrate an erbium-doped waveguide amplifier by erbium ion implantation in Si_3N_4 photonic integrated circuits, achieving 145 mW on-chip output power and more than 30 dB small-signal gain, which is on par with commercial fiber amplifiers and beyond state-of-the-art III-V heterogeneously integrated semiconductor amplifiers.

Shanghai

10:45–12:30
We2F • Photonics Enabled Sub-Terahertz and Terahertz Systems
Presider: Guillermo Carpintero; Universidad Carlos III de Madrid, Spain

We2F.1 • 10:45 **Invited**
Broadband Photon-Assisted Terahertz Sensing and Communication, Jianjun Yu[1,2], Yanyi Wang[1], Junjie Ding[1], Jiao Zhang[2], Weiping Li[1], Kaihui Wang[1], Min Zhu[2], Feng Zhao[3], Wen Zhou[1], Xiaohu You[2]; [1]*Fudan Univ., China;* [2]*Purple Mountain Laboratories, China;* [3]*Xian Univ. of Posts and Telecommunications, China.* We review our recent advance in terahertz communication and sensing. Based on photonics-aided scheme, wireless transmission of ~100Gb/s THz signal over hundreds of meters has been demonstrated. A communication capacity of 38.1 Gbit/s and a radar range resolution of 1.58 cm are simultaneously achieved in the terahertz band.

Kairo

10:45–12:30
We2G • Diamond Nanophotonic Quantum Networks
Organisers: Wolfram Pernice, University of Münster, Germany
Alexander Kubanek, Ulm University, Germany

Quantum processors promise to deliver enormous computational power for solving problems which lie beyond the capabilities of classical machines. There are many hardware platforms on which quantum computing can be developed, and it is not yet clear which technological approach will prove most successful. Photonic technologies face challenges because of the need to generate and transform the required quantum states on demand.
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 focusses 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.

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

Delhi

10:45–12:30
We2H • 8th International Symposium for Optical Interconnect in Data Centres II
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, 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.

We2A • DCI and Metro Transmission Systems—Continued

We2A.3 • 11:15
Gain-Clamped SOA Enabled Reach-Extended Self-Homodyne Coherent Bidirectional Transmission for Inter-DCI Applications, Weihao Li[1], Ming-Ming Zhang[1], Yifan Zeng[1], Yizhao Chen[1], Junda Chen[1], Yuqi Li[1], Ming Tang[1]; *[1]Huazhong Univ of Science and Technology, China.* We propose a reach-extended self-homodyne coherent bidirectional 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.

We2A.4 • 11:30 Invited
Recent Trials in ZR and XR Pluggable Technologies, Paul Wright[1]; *[1]British Telecom, UK.* This presentation looks at recent work both on field-trial networks and in lab-based experiments making use of 400G ZR pluggable modules and point-to-multipoint XR optics considering use cases for connectivity in national core, metro and aggregation networks.

We2B • Control Plane and Automation—Continued

We2B.2 • 11:15
Dynamic Upgrade/Downgrade of WDM Link Capacity in SDN-Enabled WDM VNTs Over SDM Networks, Raul Muñoz[3], Carlos Manso[3], Filippos Balasis[2], Cen Wang[1], Ricard Vilalta[3], Ramon Casellas[3], Ricardo Martinez[3], Noboru Yoshikane[1], Takehiro Tsuritani[1]; *[1]Kabushiki Kaisha KDDI Sogo Kenkyujo, Japan; [2]Kabushiki Kaisha KDDI Sogo Kenkyujo, Japan; [3]Centre Tecnologic de Telecomunicacions de Catalunya, Spain.* We present a WDM over SDM control system that detects overloaded/underloaded WDM links between ROADMs and provisions/removes virtual WDM links in response to dynamic traffic changes in SDN-enabled WDM VNTs over SDM Networks. We have experimentally validated the architecture in a WDM over SDM testbed.

We2B.3 • 11:30
Reinforcement-Learning-Based Network Design and Control with Stepwise Reward Variation and Link-Adjacency Embedding, Kenji Cruzado[1], Ryuta Shiraki[1], Yojiro Mori[1], Takafumi Tanaka[2], Katsuaki Higashimori[2], Fumikazu Inuzuka[2], Takuya Ohara[2], Hiroshi Hasegawa[1]; *[1]Nagoya Univ., Japan; [2]NTT Corporation, Japan.* We propose a reinforcement-learning-based network design and control algorithm that introduces reward variation dependent on maximum link utilization and link-adjacency embedding as input parameters. Up to 65%/20% capacity enhancement relative to first-fit and link-congestion-aware methods is verified.

We2C • Deep Learning for Optical Fiber Communications—Continued

We2D • IM/DD & Short-Reach Communications—Continued

We2D.2 • 11:15
200 Gb/s Unamplified IM/DD Transmission Over 20-km SMF With an O-Band Low-Chirp Directly Modulated Laser, Xiaodan Pang[1,2], Toms Salgals[3], Hadrien Louchet[4], Di Che[5], Markus Gruen[4], Yasuhiro Matsui[6], Thomas Dippon[4], Richard Schatz[1], Mahdieh Joharifar[1], Benjamin Krueger[4], Lu Zhang[7], Yuchuan Fan[1,2], Aleksejs Udalcovs[2], Xianbin Yu[7], Sandis Spolitis[3,8], Vjaceslavs Bobrovs[3], Sergei Popov[1], Oskars Ozolins[2,1]; *[1]Applied Physics, Kungliga Tekniska Hogskolan Skolan for teknikvetenskap, Sweden; [2]RISE Research Inst.s of Sweden AB, Sweden; [3]Inst. of Telecommunications, Rigas Tehniska universitate, Latvia; [4]Keysight Technologies Deutschland GmbH, Germany; [5]Nokia Bell Labs, USA; [6]II-VI Incorporated, USA; [7]Zhejiang Univ., China; [8]Communication Technologies Research Center, Rigas Tehniska universitate, Latvia.* 200 Gb/s IM/DD transmission over 20-km SMF is demonstrated without any optical amplifiers, achieving BER below the 6.25%-overhead HD-FEC limit, enabled by a broadband and high-power DML with low-complexity digital equalizations.

We2D.3 • 11:30
Experimental Comparison of PAM-8 Probabilistic Shaping With Different Gaussian Orders at 200 Gb/s Net Rate in IM/DD System With O-Band TOSA, Md Sabbir-Bin Hossain[1,2], Georg Böcherer[1], Youxi Lin[1], Shuangxu Li[1], Stefano Calabrò[1], Andrei-Stefan Nedelcu[1], Talha Rahman[1], Tom Wettlin[2], Jinlong Wei[1], Nebojsa Stojanovic[1], Changsong Xie[1], Maxim Kuschnerov[1], Stephan Pachnicke[2]; *[1]Munich Research Center, Huawei Technologies Duesseldorf GmbH, Germany; [2]Chair of Communications, Christian-Albrechts-Universitat zu Kiel, Germany.* For 200Gb/s net rates, cap probabilistic shaped PAM-8 with different Gaussian orders are experimentally compared against uniform PAM-8. In back-to-back and 5km measurements, cap-shaped 85-GBd PAM-8 with Gaussian order of 5 outperforms 71-GBd uniform PAM-8 by up to 2.90dB and 3.80dB in receiver sensitivity, respectively.

We2E • Programmable Photonics and Comb Lasers—Continued

We2E.3 • 11:15
InP-Si_3N_4 Dual-Laser Hybrid Source-Based Wireless Mm-Wave Communication Link Using Optical Injection Locking, Robinson C. Guzman[1]; *[1]Univ. Carlos III Madrid, Spain*. This paper presents an InP-Si_3N_4-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.

We2E.4 • 11:30
InP/Si_3N_4 Hybrid External-Cavity Laser With sub-kHz Linewidth Acting as a Pump Source for Kerr Frequency Combs, Pascal Maier[1,2], Yung Chen[1], Yilin Xu[1,2], Matthias Blaicher[1,2], Dimitri Geskus[3], Ronald Dekker[3], Junqiu Liu[4], Philipp-Immanuel Dietrich[1,2], Huanfa Peng[1], Sebastian Randel[1], Wolfgang Freude[1], Tobias Kippenberg[4,5], Christian Koos[1,2]; *[1]Inst. of Photonics and Quantum Electronics (IPQ), Karlsruher Institut fur Technologie, Germany; [2]Inst. of Microstructure Technology (IMT), Karlsruher Institut fur Technologie, Germany; [3]LioniX International BV, Netherlands; [4]Ecole Polytechnique Federale de Lausanne, Switzerland; [5]Deeplight SA, Switzerland*. We report on an InP/Si_3N_4 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 • Photonics Enabled Sub-Terahertz and Terahertz Systems—Continued

We2F.2 • 11:15 ★ Highly Scored
Demonstration of 32-Gbit/s Terahertz-Wave Signal Transmission Over 400-m Wireless Distance, Junjie Ding[1], Weiping Li[1], Yanyi Wang[1], Feng Wang[1], Bowen Zhu[1], Mingxu Wang[1], Yi Wei[1], Wen Zhou[1], Jiao Zhang[2], Min Zhu[2], Jianguo Yu[3], Feng Zhao[4], Jianjun Yu[1,2]; *[1]Fudan Univ., China; [2]Purple Mountain Laboratories, China; [3]Beijing Univ. of Posts and Telecommunications, China; [4]Xi'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.

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 Li[1], Yuxuan Tan[1], Bowen Zhu[1], Feng Wang[1], Yanyi Wang[1], Junjie Ding[1], Kaihui Wang[1], Li Zhao[1], Wen Zhou[1], Jianguo Yu[2], Feng Zhao[3], Jianjun Yu[1]; *[1]Fudan Univ., China; [2](2) Beijing Univ. of Posts and Telecommunications, China; [3](3) Xi'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.

We2G • Diamond Nanophotonic Quantum Networks—Continued

We2H • 8th International Symposium for Optical Interconnect in Data Centres II—Continued

We2A • DCI and Metro Transmission Systems—Continued

We2A.5 • 12:00 Invited

The QAMeleon Ecosystem: SDN-Enabled High-Speed Transceivers and Photonic Switches for the Next Generation of DCI and Metro Networks, Harry Zervos[1], M. Spyropoulou[1], I. Kanakis[1], K.O. Velthaus[2], G. Fiol[2], Patrick Runge[2], E. Rouvalis[3], A.G. Steffan[3], Guy Torfs[4], E. Goodbar[5], S. Kleijn[6], Aref Rasoulzadehzali[7], Nicola Calabretta[7], V. Straessle[8], M. Halter[8], N. Floery[8], T.K. Johansen[9], R. Hersent[9], A. Konczykowska[9], M. Riet[10], Haik Mardoyan[11], F. Boitier[11], Sylvain Almonacil[11], Jeremie Renaudier[11], B.G. Saavedra[12], E. Giacoumidis[12], Andre Richter[12], Theoni Alexoudi[13], G. Patsamanis[13], P.G. Giardina[14], P. Piscione[14], Annachiara Pagano[15], A. Chiado Piat[15], G. Wood[16], Hercules Avramopoulos[1]; *[1]Photonics Communications Research Laboratory, Ethniko Metsobio Polytechneio, Greece; [2]Fraunhofer Heinrich Hertz Institut, Germany; [3]II-VI Incorporated, Sweden; [4]IMEC, Ghent Univ., Belgium; [6]SMART Photonics BV, Netherlands; [7]Inst. of Photonic Integration, Technische Universiteit Eindhoven, Netherlands; [8]Vario-Optics AG, Switzerland; [9]Department of Electrical Engineering, Technical Univ. of Denmark, Denmark; [10]III-V Lab, France; [11]Nokia Bells Labs, France; [12]VPIphotonics GmbH, Germany; [13]Center for Interdisciplinary Research and Innovation, Aristotle Univ. of Thessalonki, Greece; [14]Nextworks, Italy; [15]TIM Telecom Italia, Italy; [16]TUV Nord, ALTER Technology Group, UK.* The QAMeleon project is developing novel, ultra-fast and energy efficient sliceable bandwidth-variable 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 developed QAMeleon components, modules and subsystems is presented.

We2B • Control Plane and Automation—Continued

We2B.4 • 11:45

First Demonstration of Real-Time Optical Path Control Scheme with AMCC Telemetry, Hiroshi Ou[1], Kota Asaka[1], Tatsuya Shimada[1], tomoaki yoshida[1]; *[1]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.

We2C • Deep Learning for Optical Fiber Communications—Continued

We2C.2 • 11:45

Nonlinear Equalization for Optical Communications Based on Entropy-Regularized Mean Square Error, Francesca Diedolo[1], Georg Böcherer[2], Maximilian Schaedler[2], Stefano Calabrò[2]; *[1]Technische Universitat Munchen, Germany; [2]Huawei Technologies Deutschland GmbH, Germany.* An entropy-regularized mean square error (MSE-X) cost function is proposed for nonlinear equalization of short-reach optical channels. For a coherent optical transmission experiment, MSE-X achieves the same bit error rate as the standard MSE cost function and a significantly higher achievable information rate.

We2C.3 • 12:00

Learning Optimal PAM Levels for VCSEL-Based Optical Interconnects, Muralikrishnan Srinivasan[1], Jinxiang Song[1], Christian Häger[1], Krzysztof Szczerba[2], Henk Wymeersch[1], Jochen B. Schroeder[1]; *[1]Chalmers Univ. of Technology, Sweden; [2]Juniper Networks Inc, USA.* An auto-encoder that optimizes a VCSEL-based fiber-optic system end-to-end and provides a 1.5dB sensitivity gain at higher temperatures is trained, utilizing a neural network that models the response of a VCSEL for a range of operating temperatures.

We2D • IM/DD & Short-Reach Communications—Continued

We2D.4 • 11:45

56 Gbaud PAM-4 Transmission Equalization Using Implicitly Masked Parallel Micro-Ring Resonator Reservoir Computing, Sebastian Kühl[1], Lars E. Kruse[1], Stephan Pachnicke[1]; *[1]Chair of Communications, Christian-Albrechts-Universitat zu Kiel, Germany.* We show that variation of the coupling ratios of parallel micro-ring resonators can replace masking in time-delay reservoir computing while being line-speed capable. Superior BER performance is demonstrated compared to previous photonic reservoirs and Kramers-Kronig DSP for a 100 km 56 Gbaud PAM-4 transmission.

We2D.5 • 12:00

Experiments on Bipolar Transmission with Direct Detection, Thomas Wiegart[1], Daniel Plabst[1], Tobias Prinz[1], Talha Rahman[2], Maximilian Schaedler[2], Nebojsa Stojanovic[2], Stefano Calabrò[2], Norbert Hanik[1], Gerhard Kramer[1]; *[1]Inst. for Communications Engineering, Technische Universitat Munchen, Germany; [2]Munich Research Center, Huawei Technologies Deutschland GmbH, Germany.* Achievable information rates of bipolar 4- and 8-ary constellations are experimentally compared to those of intensity modulation (IM) when using an oversampled direct detection receiver. The bipolar constellations gain up to 1.8 dB over their IM counterparts.

We2E • Programmable Photonics and Comb Lasers—Continued

We2E.5 • 11:45
Coherent Expansion of a Gain-Switched Optical Frequency Comb Employing a Dual-Stage Active Demultiplexer, Prajwal Doddaballapura Lakshmijayasimh[1], Aleksandra Kaszubowska-Anandarajah[1,2], Eamonn P. Martin[1], Manas Srivastava[1], Syed Tajammul Ahmad[1], Prince Anandarajah[1,2]; *[1]The Photonic Systems and Sensing Lab., Dublin City Univ., Ireland; [2]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.

We2E.6 • 12:00 Invited
Silicon Photonic MEMS for Programmable Photonics, Sangyoon Han[1]; *[1]DGIST, Korea.* 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.

We2F • Photonics Enabled Sub-Terahertz and Terahertz Systems—Continued

We2F.4 • 11:45
Real-Time Dual-Channel 2 × 2 MIMO Fiber-THz-Fiber Seamless Integration System at 385 GHz and 435 GHz, Jiao Zhang[1,2], Min Zhu[1,2], Bingchang Hua[2], Mingzheng Lei[2], Yuancheng Cai[1,2], Liang Tian[2], Yucong Zou[2], Like Ma[3], Yongming Huang[1,2], Jianjun Yu[2,4], Xiaohu You[1,2]; *[1]Southeast Univ., China; [2]Purple Mountain Laboratories, China; [3]China Mobile Research Inst., China; [4]Fudan Univ., China.* 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.

We2F.5 • 12:00
Experimental Demonstration of Reconfigurable Microwave Signal Processing Using a Dispersion-Tailored Few-Mode Fiber, Elham Nazemosadat[1], Ivana Gasulla Mestre[1]; *[1]ITEAM Research Inst., Universitat Politecnica de Valencia, Spain.* 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.

We2G • Diamond Nanophotonic Quantum Networks—Continued

We2H • 8th International Symposium for Optical Interconnect in Data Centres II—Continued

Samarkand + Osaka	Singapore	Sydney	Rio
We2A • DCI and Metro Transmission Systems—Continued	**We2B • Control Plane and Automation—Continued**	**We2C • Deep Learning for Optical Fiber Communications—Continued**	**We2D • IM/DD & Short-Reach Communications—Continued**

We2C.4 • 12:15
Phase Retrieval Receiver Based on Deep Learning for Minimum-Phase Signal Recovery, Daniele Orsuti[1], Cristian Antonelli[2], Alessandro Chiuso[1], Marco Santagiustina[1], Antonio Mecozzi[2], Andrea Galtarossa[1], Luca Palmieri[1]; *[1]Dipartimento di Ingegneria Dell'Informazione, Universita degli Studi di Padova Dipartimento di Ingegneria Dell'Informazione, Italy; [2]Dipartimento 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

We2E • Programmable Photonics and Comb Lasers—Continued

We2F • Photonics Enabled Sub-Terahertz and Terahertz Systems—Continued

We2G • Diamond Nanophotonic Quantum Networks—Continued

We2H • 8th International Symposium for Optical Interconnect in Data Centres II—Continued

We2F.6 • 12:15
End-to-End Demonstration of an SDN-Reconfigurable, FPGA-Based TxRx Interface for Analog-IFoF/MmWave X-Haul, Konstantina Kanta[1], Panagiotis Toumasis[1], Giannis Giannoulis[1], Ioannis Stratakos[1], George Lentaris[1], Elissaios-Alexios Papatheofanous[2], Ioanna Mesogiti[3], Eleni Theodoropoulou[3], Aristotelis Margaris[6], Dimitris Syrivelis[4], Evrydiki Kyriazi[1], George Brestas[1], Kostas Tokas[4], Nikos Argyris[4], Chris Vagionas[5], Ronis Maximidis[5], Paraskevas Bakopoulos[4], Agapi Mesodiakaki[5], Marios Gkatzianas[5], Georgios Kalfas[5], Kostas Tsagkaris[6], Nikos Pleros[5], Dionysios Reisis[2], George Lyberopoulos[3], Dimitrios Apostolopoulos[1], Dimitrios Soudris[1], Hercules Avramopoulos[1]; *[1]ICCS/NTUA, Greece; [2]Electronics Laboratory, Department of Physics, NKUA, Greece; [3]Cosmote Mobile Telecommunications SA, Greece; [4]NVIDIA, Greece; [5]Department of Informatics, Aristoteleio Panepistemio Thessalonikes, Greece; [6]Incelligent 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

Samarkand + Osaka

13:30–15:15
We3A • Topological Complex Light in Fibers and Devices
Presider: Marco Santagiustina; Universita degli Studi di Padova, Italy

We3A.1 • 13:30 Tutorial
Spatially, Vectorially and Topologically Complex Light in Fibers: Implications & Applications, Siddharth Ramachandran[1]; [1]*Boston Univ., USA.* 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.

Singapore

13:30–15:15
We3B • QoT Estimation
Presider: Marco Ruffini, Ireland

We3B.1 • 13:30
Accuracy of Nonlinear Interference Estimation on Launch Power Optimization in Short-Reach Systems with Field Trial, Toru Mano[1], Andrea D'Amico[2], Emanuele E. Virgillito[2], Giacomo Borraccini[2], Yue-Kai Huang[3], Kei Kitamura[1], Kazuya Anazawa[1], Akira Masuda[1], Hideki Nishizawa[1], Ting Wang[3], Koji Asahi[4], Vittorio Curri[2]; [1]*Nihon Denshin Denwa Kabushiki Kaisha, Japan;* [2]*Politecnico di Torino, Italy;* [3]*NEC Laboratories America Inc, USA;* [4]*Nihon Denki Kabushiki Kaisha, Japan.* We show that even the approximate formula of the Gaussian noise model is accurate enough for launch power optimization in short-reach systems. We compare simulation and field trial results using two fiber types, showing the estimation error of signal Q-factor is less than 0.02 dB.

We3B.2 • 13:45
Fourier Neural Operator Based Fibre Channel Modelling for Optical Transmission, Qizhi Qiu[1], Huazhi Lun[1], Xiaomin Liu[1], Lilin Yi[1], Weisheng Hu[1], Qunbi Zhuge[1]; [1]*Shanghai Jiao Tong Univ., China.* 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.

We3B.3 • 14:00
Mitigation of Anomaly Loss in Optical Transmission System with Hybrid EDFA/Raman Amplification, Inwoong Kim[1], Olga Vassilieva[1], Paparao Palacharla[1]; [1]*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 SNR_{ASE} provides better impairment mitigation than equalizing output power for the affected span in transmission link.

Sydney

13:30–15:15
We3C • Coding and Modulation
Presider: Xi Chen; Nokia Bell Labs, USA

We3C.1 • 13:30
Low-Complexity Symbol Demapping for Multidimensional Multilevel Coded Modulation, Tsuyoshi Yoshida[1,2], Koji Igarashi[2], Magnus Karlsson[3], Erik Agrell[3]; [1]*Information Technology R&D Center, Mitsubishi Electric Corporation, Japan;* [2]*Graduate School of Engineering, Osaka Univ., Japan;* [3]*Fiber Optic Communications Research Center, Chalmers Univ. of Technology, Sweden.* Symbol demapping for multidimensional multilevel coding (MLC) is proposed, together with a novel nonsystematic encoding method, applicable to any dimensionality. The complexity of soft-decision forward error correction and symbol demapping, both normally problematic in multidimensional MLC, is reduced, which enables high-throughput implementation.

We3C.2 • 13:45
DFE State-Tracking Demapper for Soft-Input FEC in 800G Data Center Interconnects, Kaiquan Wu[2], Gabriele Liga[2], Jeffrey Lee[2], Lotte M. Paulissen[2], Jamal Riani[1], Alex Alvarado[2]; [1]*Marvell Semiconductor Inc, USA;* [2]*Technische Universiteit Eindhoven, Netherlands.* A simple one-step state model is used to track the DFE error propagation for 4-PAM. The knowledge of DFE output states is used to improve LLR accuracy. Demapping via DFE state tracking outperforms bit-interleaving and precoding schemes for the 802.3ca LDPC code by 0.76 dB.

We3C.3 • 14:00
Power-Efficient and Robust Nonlinear Demapper for 64QAM Using in-Memory Computing, Amro Eldebiky[1], Georg Böcherer[2], Grace Li Zhang[1], Bing Li[1], Maximilian Schaedler[2], Stefano Calabrò[2], Ulf Schlichtmann[1]; [1]*Technical Univ. of Munich, Germany;* [2]*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.

Rio

13:30–15:15
We3D • High-Speed Transmission
Presider: Lidia Galdino; Univ. College London, UK

We3D.1 • 13:30 Invited
Real-Time 1.6Tb/s Super-Channel Transmission Using a Vertically Integrated 100 GBd PCS-64QAM Coherent MODEM, Robert Maher[1]; [1]*Infinera Corporation, USA.* The performance of a commercially available vertically integrated 100GBd PCS-64QAM digital coherent MODEM is reviewed. Record transmission reach for real-time 1.6Tb/s (2x800G) super-channels in a fully loaded C- and L-band transmission system is demonstrated.

We3D.2 • 14:00 ★ Highly Scored
Transmission of 160.7-GBaud 1.64-Tbps Signal Using Phase-Interleaving Optical Modulator and Digital Spectral Weaver, Hiroshi Yamazaki[1,2], Yoshihiro Ogiso[3], Masanori Nakamura[1], Teruo Jyo[2], Munehiko Nagatani[1,2], Josuke Ozaki[3], Takayuki Kobayashi[1], Toshikazu Hashimoto[2], Yutaka Miyamoto[1]; [1]*NTT Network Innovation Laboratories, Japan;* [2]*NTT Device Technology Laboratories, Japan;* [3]*NTT Device Innovation Center, Japan.* We demonstrate a bandwidth-extending transmitter employing an 8×4 digital spectral weaver, CMOS DACs, and an InP integrated phase-interleaving optical modulator. The transmitter generates single-carrier 160.7-GBaud signals achieving net data rates of 1.68 Tbps back-to-back and 1.64 Tbps after 80-km SSMF transmission.

Boston

13:30–15:15
We3E • Passive Photonic Functions
Presider: Dan Marom; Hebrew Univ. of Jerusalem, Israel

We3E.1 • 13:30
Compact, Spatial-Mode-Interaction-Free, Ultralow-Loss, Nonlinear Photonic Integrated Circuits, Xinru Ji[1], Junqiu Liu[1], Jijun He[1], Rui N. Wang[1], Zheru Qiu[1], Johann Riemensberger[1], Tobias Kippenberg[1]; *[1]Ecole Polytechnique Federale 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.

We3E.2 • 13:45
Ultra-Broadband Silicon Dual-Polarization Mode-Order Converter Assisted with Subwavelength Gratings, Zhe Yuan[1], Yongchen Wang[1], Mengfan Cheng[1], Qi Yang[1], Ming Tang[1], Deming Liu[1], Lei Deng[1]; *[1]Huazhong Univ. of Science and Technology, China.* We demonstrate an ultra-broadband dual-polarization mode-order converter using subwavelength gratings. The device with 1dB bandwidth over 380nm is achieved in simulation. The fabricated device has low insertion loss (<1.59dB), low crosstalk (<-15.6dB), and 1dB bandwidth exceeds 80nm which is larger than the reported highest level.

We3E.3 • 14:00
1×40 100 GHz Spacing Low-Crosstalk Mux/Demux Based on Cascaded Planar Echelle Gratings on 3-μm Silicon Platform, Yu Wang[1], Mikko Harjanne[2], Srivathsa Bhat[2], Giovanni Delrosso[2], Nicola Calabretta[1]; *[1]Technische Universiteit Eindhoven, Netherlands; [2]Teknologian tutkimuskeskus VTT Oy, Finland.* We experimentally demonstrate a photonic integrated 1×40 100GHz spaced Mux/Demux by cascading one 1×8 100GHz 3-μm silicon Planar Echelle Grating (PEG) and eight 1×5 800GHz PEGs. Experimental results show 2dB insertion loss, -35dB crosstalk and error-free operation at 10Gb/s with <0.1dB power penalty.

Shanghai

13:30–15:15
We3F • Indoor and VLC Systems and Technologies
Presider: Harald Haas; Univ. of Strathclyde, UK

We3F.1 • 13:30
Indoor Optical Wireless Communications With WDM-OFDMA Enabled by an Optical Hotspot with a Wide Field-of-View, Feng Feng[3], Paramin Sangwongngam[1], Hyunchae Chun[2], Grahame Faulkner[1], Dominic O'Brien[1]; *[1]Univ. of Oxford, UK; [2]Incheon National Univ., Korea (the Republic of); [3]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.

We3F.2 • 13:45
Full-Duplex Bidirectional Indoor Steerable OWC System Using Orthogonal Polarization States, Ngoc Quan Pham[1], Ketema A. Mekonnen[1], Ali Mefleh[2], Ton Koonen[1], Eduward Tangdiongga[1]; *[1]Eindhoven Univ. of Technology, Netherlands; [2]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.

We3F.3 • 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, Deng-Cheng Tsai[1], Yun-Han Chang[1], Shang-Yen Tsai[1], Li-Sheng Hsu[1], Chi-Wai Chow[1], Ching-Wei Peng[1], Yuan-Zeng Lin[1], Yin-He Jian[1], Yang Liu[2], Chien-Hung Yeh[3]; *[1]National Yang Ming Chiao Tung Univ., Taiwan; [2]Philips, Hong Kong; [3]Feng Chia Univ., Taiwan.* We propose and preset the first demonstration of a record high 298.8-kbit/s.m bit-rate distance product rolling-shutter image-sensor based free-space-optical-communication (FSO) system. Long-short-term-memory-neural-network (LSTM-NN) is utlized to decode the 4-level pulse-amplitude-modulation (PAM4) rolling-shutter pattern.

Kairo

13:30–15:15
We3G • Quantum Communications - How Will Quantum Technology Revolutionalize the Internet?
Organisers: Stephan Pachnicke, Kiel University, Germany
Michela Svaluto Moreolo, CTTC, Spain
Paola Parolari, Politecnico di Milano, Italy

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.

Delhi

13:30–15:15
We3H • 8th International Symposium for Optical Interconnect in Data Centres III
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, 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.

Samarkand + Osaka

We3A • Topological Complex Light in Fibers and Devices—Continued

We3A.2 • 14:30
Broadband 15-Mode Multiplexers Based on Multi-Plane Light Conversion With 8 Planes in Unwrapped Phase Space, Nicolas K. Fontaine[1], Mikael Mazur[1], Roland Ryf[1], Lauren Dallachiesa[1], Haoshuo Chen[1], David T. Neilson[1], Cris Bolle[1], Joel Carpenter[2]; *[1]Nokia Bell Labs, USA; [2]School 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 8π phase wraps to enable 200~nm operation bandwidth with significantly reduced wavelength dependence compared to traditional 2π designs.

We3A.3 • 14:45
Design and Fabrication of Three-Dimensional Polymer Optical Waveguide-Based Fan-in/out Device for Multicore Fibers, Yuto Yamaguchi[1]; *[1]Keio Gijuku Daigaku Rikogakubu Daigakuin Rikogaku Kenkyuka, Japan.* In this paper, a compact (10-mm long) and low-loss fan-in/-out polymer waveguide is successfully fabricated using the Mosquito method, in which four cores three-dimensionally vary their arrangemnent from one end to the other and they are precisely aligned to couple to a multicore fiber.

Singapore

We3B • QoT Estimation—Continued

We3B.4 • 14:15
Quantifying Features' Contribution for ML-Based Quality-of-Transmission Estimation Using Explainable AI, Omran Ayoub[1], Davide Andreoletti[1], Sebastian Troia[2], Silvia Giordano[1], Cristina Rottondi[3], Andrea Bianco[3]; *[1]Department of Innovative Technologies, Scuola universitaria professionale della Svizzera italiana, Switzerland; [2]Politecnico di Milano, Italy; [3]Politecnico 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.

We3B.5 • 14:30
Optical Signal Spectrum Prediction Using Machine Learning and in-Line Channel Monitors in a Multi-Span ROADM System, Zehao Wang[1], Emmanuel Akinrintoyo[2], Daniel Kilper[2], Tingjun Chen[1]; *[1]Electrical and Computer Engineering, Duke Univ., USA; [2]CONNECT 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 EDFAs under varying channel loading configurations.

We3B.6 • 14:45 Invited
GNPy: Lessons Learned and Future Plans, Jan Kundrát[1,2], Esther Le Rouzic[3], Jonas Mårtensson[4], Stefan Melin[5], Andrea D'Amico[6], Gert Grammel[7], Gabriele Galimberti[8], Vittorio Curri[6]; *[1]CESNET, Czechia; [2]Telecom Infra Project, USA; [3]Orange Innovation / Network, France; [4]RISE, Sweden; [5]Telia, Sweden; [6]Politecnico di Torino, Italy; [7]Juniper Networks, Germany; [8]Cisco Photonics, Italy.* We discuss the history, past challenges and future plans of GNPy, an open source project for simulating physical impairments in contemporary DWDM network. The paper describes the unique interaction among network operators, equipment vendors, and standard bodies, as well as challenges in implementing the digital twin of an optical network.

Sydney

We3C • Coding and Modulation—Continued

We3C.4 • 14:15 Invited
Probabilistic Constellation Shaping and Subcarrier Multiplexing for Nonlinear Fiber Channels, Junho Cho[1], Han Sun[1]; *[1]Infinera 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.

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, Masanori Nakamura[1], Fukutaro Hamaoka[1], Takeo Sasai[1], Minami Takahashi[1], Takayuki Kobayashi[1], Yoshiaki Kisaka[1], Yutaka Miyamoto[1]; *[1]NTT Network Innovation Laboratories, Japan.* We achieved a 17.57-bit/4Dsymbol information rate with >562-Gb/s net rate based on precisely entropy and code-rate optimized 32-GBaud probabilistically constellation-shaped (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.

Rio

We3D • High-Speed Transmission—Continued

We3D.3 • 14:15 ★ Highly Scored
Record 2.29 Tb/s GS-256QAM Transmission Using a Single Receiver, Benedikt Geiger[1,2], Eric Sillekens[1], Filipe Ferreira[1], Robert Killey[1], Lidia Galdino[1], Polina Bayvel[1]; *[1]Univ. College London, UK; [2]Karlsruher Institut fur Technologie, Germany.* 8 x 26GBd DP-GS256QAM super-channel with a net data rate of 2.29Tb/s was received after 75km transmission using a single 211-GHz optical receiver. The use of digital pre-distortion and tailored geometric constellation shaping led to an improvement of 1.2bit/4D-sym in the achievable information rate.

We3D.4 • 14:30
Silicon Photonics IQ Modulator Targeted for 800ZR Data Center Interconnection, Jian Wang[1], Wen-Jr Jiang[1], You-Wei Chen[1,2], Mustafa Al-Qadi[1], Kangmei Li[1], Konstantin Kuzmin[1], Jason Ackert[1], David Dougherty[1], Weilin Liu[1], Chengkun Chen[1], Hiroaki Yamada[1], Calvin Ho[1], Ping Wang[1], Yan Yang Zhao[1], Yifeng Zhou[1], Xu Liu[1], Kevin Schmidt[1], Jocelyn Nee[1], Ken McGreer[1], Marcel Boudreau[1], Jibin Sun[1], Winston Way[1], Hui Xu[1]; *[1]NeoPhotonics Corp, USA; [2]MediaTek USA Inc., USA.* An all-silicon polarization-multiplexed modulator is demonstrated for the first time at 120GBaud-16QAM over 100-km SSMF, achieving per-polarization output power of -18.7dBm and rOSNR of 23.5dB at oFEC BER threshold. A BER of 1.4e-3 was obtained with a 63-GHz scope without sophisticated DSP or optical equalization.

We3D.5 • 14:45
Net 556.8 Gbps/pol Coherent Transmission Enabled by a Two-Segment All-Silicon Modulator, Zibo Zheng[1,2], Abdolkhalegh Mohammadi[1], Xiaoguang Zhang[2], Leslie Rusch[1], Wei Shi[1]; *[1]COPL, Universite Laval, Canada; [2]Electrical 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 124GB-16QAM, 120GB-32QAM and 116GB-64QAM, enabling a maximum 556.8 Gbps/polarization net line rate.

We3E • Passive Photonic Functions—Continued

We3E.4 • 14:15
Ultra-Dense Waveguide Arrays for Photonic Integrated Circuit, Ting Li[1], Peiji Zhou[1], Yucheng Lin[1], Lipeng Xia[1], Xiaochuan Xu[2], 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.

We3E.5 • 14:30
Integrated Optical Phased Array for Circularly Polarized Orbital Angular Momemtum Multiplexing, Yuxuan Chen[1], Simon Levasseur[1], Leslie Rusch[1], Wei Shi[1]; *[1]Department of Electrical and Computer Engineering, Center for Optics, Photonicsand Lasers (COPL), Universite Laval, Canada*. We design and demonstrate an on-chip tunable optical phased array that generates multiplexed circularly polarized Orbital Angular Momemtum modes with record performance (24 simultaneous modes, -16.4dB worst-case crosstalk).

We3E • 14:45 Invited
The Role of Europe in Photonic Industry, Martin Vallo[1]; *[1]Yole Group, France*. Abstract not available.

We3F • Indoor and VLC Systems and Technologies—Continued

We3F.4 • 14:15
Multi-Gigabits per Second Spatial Multiplexing Transmission Using Passive OFE and WDM-Over-POF, Carina Ribeiro Barbio Corrêa[1], Ketema A. Mekonnen[1], Frans M. Huijskens[1], Ton Koonen[1], Eduward Tangdiongga[1]; *[1]Eindhoven Univ. of Technology, Netherlands*. Indoor networks should be simple and enable multi-Gbps wireless links at low costs. Spatial multiplexing links from multiple optical access points using WDM-over-POF feeder and passive optical front ends are presented. Using discrete multitone on two colours we can double the throughput to 5.2 Gbps.

We3F.5 • 14:30
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.

We3F.6 • 14:45 Invited
Visible Light Communication Toward 6G: Key Technologies and Future Perspective, Nan Chi[1]; *[1]Fudan Univ., China*. Abstract not available.

We3G • Quantum Communications - How Will Quantum Technology Revolutionalize the Internet?—Continued

We3H • 8th International Symposium for Optical Interconnect in Data Centres III—Continued

Samarkand + Osaka

We3A • Topological Complex Light in Fibers and Devices—Continued

We3A.4 • 15:00
Highly Reliable and Low-Loss Bent Polarization Maintaining Fiber with High Polarization Extinction Ratio, Haruki Kitao[1], Tsutaru Kumagai[1], Tetsuya Nakanishi[1]; [1]*Sumitomo 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.

Singapore

We3B • QoT Estimation—Continued

Sydney

We3C • Coding and Modulation—Continued

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

Rio

We3D • High-Speed Transmission—Continued

We3D.6 • 15:00
Phenomenological Characterization of the Electronically Enhanced Phase Noise in Transmission Experiments, Xiaoyan Ye[1], Amirhossein Ghazisaeidi[1], Sylvain Almonacil[1], Haik Mardoyan[1], Jeremie Renaudier[1]; [1]*Nokia 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*

Boston	Shanghai	Kairo	Delhi
We3E • Passive Photonic Functions—Continued	We3F • Indoor and VLC Systems and Technologies—Continued	We3G • Quantum Communications - How Will Quantum Technology Revolutionalize the Internet?—Continued	We3H • 8th International Symposium for Optical Interconnect in Data Centres III—Continued

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

Samarkand + Osaka

15:45–17:00
We4A • Scattering and Nonlinear Effects in Fibers
Presider: Rogerio Nogueira; Instituto De Telecomunicacoes, Portugal

We4A.1 • 15:45 ★ Highly Scored
Broadband Incoherently Pumped Raman Amplification for Ultra-Long Span U-Band Transmission Systems, Natsupa Taengnoi[1], Kyle Bottrill[1], Yang Hong[1], Lajos Hanzo[2], Periklis Petropoulos[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Electronics and Computer Science, Univ. of Southampton, UK.* We demonstrate broadband incoherently pumped U-band distributed Raman amplification for ultra-long span communications. 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[1], Francesco Da Ros[1], Andrea Carena[2], Darko Zibar[1]; [1]*Technical Univ. of Denmark, Denmark;* [2]*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 Invited
Stimulated Brillouin Scattering in Chiral Photonic Crystal Fibre, Xinglin Zeng[1], Birgit Stiller[1]; [1]*Max-Planck-Inst., Science of Light, 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.

Singapore

15:45–17:30
We4B • Optical Networks for Sensing and Sensing for Optical Networks
Presider: Anna Tzanakaki, Univ. of Athens, Greece

We4B.1 • 15:45 Invited
Distributed Fiber Sensing Applications, Glenn Wellbrock[1]; [1]*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[1], Chuan Li[2], Zhe Liu[2], Tao Zhang[2], Sheng Liu[1], Dawei Ge[1], Yuren You[2], Jibiao Zhang[2], Dong Wang[1], Yang Zhao[1], Dechao Zhang[1], Han Li[1]; [1]*China Mobile Research Inst., China;* [2]*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%.

Sydney

15:45–17:30
We4C • Digital Signal Processing for Novel Applications
Presider: Elie Awwad; Telecom Paris, France

We4C.1 • 15:45 Invited
Digital Signal Processing for CV-QKD, Imran Khan[1]; [1]*Max-Planck-Inst Physik des Lichts, Germany.* Abstract not available.

We4C.2 • 16:15
Improved Pre-Compensation to Combat Power Fading in IM/DD Systems, Tom Wettlin[1], Stefano Calabrò[2], Talha Rahman[2], Md Sabbir-Bin Hossain[1,2], Jinlong Wei[2], Nebojsa Stojanovic[2], Stephan Pachnicke[1]; [1]*Christian-Albrechts-Universitat zu Kiel, Germany;* [2]*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 GBd.

Rio

15:45–17:15
We4D • Wide-band Technologies and Transmission
Presider: Fatima Garcia Gunning; Tyndall National Inst., Ireland

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, Shimpei Shimizu[1], Takayuki Kobayashi[1], Takushi Kazama[1], Takeshi Umeki[1], Masanori Nakamura[1], Koji Enbutsu[1], Takahiro Kashiwazaki[1], Fukutaro Hamaoka[1], Munehiko Nagatani[1], Hiroshi Yamazaki[1], Kei Watanabe[1], Yutaka Miyamoto[1]; [1]*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) inline optical amplification with >15-dB gain using the proposed configuration under a 125-GHz-spaced 67-channel 800-Gbps/λ WDM transmission condition.

We4D.2 • 16:00
Capacity of Phase-Sensitively Preamplified Optical Links at low Signal-to-Noise Ratio, Kovendhan Vijayan[1], Ali Mirani[1], Jochen B. Schroeder[1], Magnus Karlsson[1], Peter Andrekson[1]; [1]*Chalmers tekniska hogskola, Sweden.* We experimentally show that phase-sensitively 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 Direct-Detection Transmission in the O-Band, Yang Hong[1], Natsupa Taengnoi[1], Kyle Bottrill[1], Yu Wang[1], Jayanta K. Sahu[1], Periklis Petropoulos[1], David Richardson[1]; [1]*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 SD-FEC limit in experiments with two different channel spacings.

Boston

15:45–17:30
We4E • Silicon Photonics
Presider: Timo Aalto; VTT Technical Research Centre of Finland, Finland

We4E.1 • 15:45 Invited
High Baudrate Silicon Photonics for the Next-Generation Optical Communication, Xi Xiao[2,3], Lei Wang[1,3], Ming Luo[2], Xiao Hu[1,2], Daigao Chen[1,2], Hongguang Zhang[1,2], Yuguang Zhang[1], Peng Feng[1,2], Jin Tao[2], Yanfeng Fu[1], Dong Wang[1], Zhixue He[3,2], Shaohua Yu[3,2]; *[1]National Information Optoelectronics Innovation Center, China; [2]China Information and Communication Technologies Group Corporation (CICT), China; [3]Peng Cheng Laboratory, China.* A silicon photonic integrated coherent transmit & receive optical sub-assembly with the baud rate beyond 100Gbaud is developed for the next-generation optical communications. Based on this device, 1.06Pb/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, Weiwei Zhang[1], Arian Hashemi[2], Martin Ebert[1], Ke Li[1], Minwo Wang[2], Bigeng Chen[1], Graham Reed[1], Azita Emami[2], David Thomson[1]; *[1]Univ. of Southampton, UK; [2]California 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 TDECQ and 2.4 pJ/bit power consumption.

Shanghai

15:45–17:15
We4F • Satellite Based Optical Freespace Communication II
Presider: Reto Muff; Thales Alenia Space France, France

We4F.1 • 15:45 Tutorial
Satellite-Based Quantum Key Distribution, Christoph Marquardt[1]; *[1]Max-Planck-Institut fur 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.

Kairo

15:45–17:30
We4G • Photonic-Electronic Memristors for Neuromorphic Applications
Organiser: Alexandros Emboras, ETH Zurich, Switzerland

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 highspeed 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.

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

Delhi

15:45–17:30
We4H • 8th International Symposium for Optical Interconnect in Data Centres IV
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, 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.

We4A • Scattering and Nonlinear Effects in Fibers—Continued

We4A.4 • 16:45
Reflectometric Measurements of Fibre-Based Orthogonal-Pump FWM Systems, Hao Liu[1], Kyle Bottrill[1], Ali Masoudi[1], Valerio Vitali[1], Periklis Petropoulos[1]; *[1]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.

We4B • Optical Networks for Sensing and Sensing for Optical Networks—Continued

We4B.3 • 16:30
Data Augmentation to Improve Machine Learning for Optical Network Failure Management, Lareb Zar Khan[1], João Pedro[2], Nelson Costa[2], Antonio Napoli[3], Nicola Sambo[1]; *[1]Scuola Superiore Sant'Anna, Italy; [2]Infinera Corp, Portugal; [3]Infinera Corp, Germany.* A variational-autoencoder based data augmentation technique was investigated to improve the quality and increase the amount of data for optical network failure management. Augmentation provided significant performance improvement in terms of reduction in machine-learning training time for soft-failure detection (37.56%) and cause identification (66.5%).

We4B.4 • 16:45
Suspect Fault Screening Assisted Graph Aggregation Network for Intra-/Inter-Node Failure Localization in ROADM-Based Optical Networks, Ruikun Wang[1], Jiawei Zhang[1], Shuangyi Yan[2], Chuidian Zeng[1], Hao Yu[3], Zhiqun Gu[1], Bojun Zhang[1], Tarik Taleb[3], Yuefeng Ji[1]; *[1]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China; [2]High Performance Networks Group, Smart Internet Lab, Univ. of Bristol, UK; [3]Centre for Wireless Communications, Oulun Yliopisto Tieto- ja sahkotekniikan tiedekunta, Finland.* We propose a suspect fault screening assisted graph aggregation network for intra-/inter-node failure localization in ROADM-based optical networks, which is validated in both simulated topology and testbed. Results show that it achieves satisfactory accuracy under different percentage of OPMs and the number of service requests.

We4C • Digital Signal Processing for Novel Applications—Continued

We4C.3 • 16:30
Improved Polarization Tracking in the Presence of PDL, Mohammad Farsi[1], Christian Häger[1], Magnus Karlsson[2], Erik Agrell[1]; *[1]Department of Electrical Engineering, Chalmers tekniska hogskola, Sweden; [2]Department of Microtechnology and Nanoscience, Chalmers tekniska hogskola, 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.

We4C.4 • 16:45
Few-bit Quantization of Neural Networks for Nonlinearity Mitigation in a Fiber Transmission Experiment, Jamal Darweesh[1], Nelson Costa[2], Antonio Napoli[3], Bernhard Spinnler[3], Yves Jaouen[1], Mansoor Yousefi[1]; *[1]Telecom-paris, France; [2]Infinera, Portugal; [3]Infinera G, Germany.* A neural network is quantized for mitigation of nonlinear 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.

We4D • Wide-band Technologies and Transmission—Continued

We4D.4 • 16:30
S+C+L-Band WDM Transmission Using 400-Gb/s Real-Time Transceivers Extended by PPLN-Based Wavelength Converter, Tomoyuki Kato[1], Hidenobu Muranaka[1], Yu Tanaka[1], Yuichi Akiyama[1], Takeshi Hoshida[1], Shimpei Shimizu[2], Takayuki Kobayashi[2], Takushi Kazama[2], Takeshi Umeki[2], Kei Watanabe[2], Yutaka Miyamoto[2]; *[1]Fujitsu Kabushiki Kaisha Kawasaki Kojo, Japan; [2]Nihon Denshin Denwa Kabushiki Kaisha, Japan.* Extended utilization of S-band based on common-band transceivers employing PPLN-based wavelength converters and distributed Raman amplification was investigated to achieve S+C+L-band WDM transmission above 14 THz. We demonstrated 100-km SSMF transmission of 64-ch 400-Gb/s DP-16QAM real-time signal in the S-band co-propagating with the C+L-band.

We4D.5 • 16:45
Real-Time 59.2 Tb/s Unrepeated Transmission Over 201.6 km Using Ultra-Wideband SOA as High Power Booster, Xiaohui Zhao[1], Dylan Le Gac[1], Salma Escobar Landero[1], Iosif Demirtzioglou[1], Abel Lorences-Riesgo[1], Loig Godard[1], Nayla El Dahdah[1], Ge Gao[1], Romain Brenot[1], Yann Frignac[1], Gabriel Charlet[1]; *[1]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 • Silicon Photonics—Continued

We4E.3 • 16:30
Ultra-High-Q Racetrack on Thick SOI Platform Through Hydrogen Annealing, Yisbel Marin[1], Arijit 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.

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[2], Masataka Noguchi[3], Shigeki Takahashi[4], Kasidit Toprasertpong[1], Shinichi Takagi[1], 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.

We4F • Satellite Based Optical Freespace Communication II—Continued

We4F.2 • 16:45 Invited
How Far Could we Stretch the Capacity of Optical Satellite Communications?, Sebastien Bigo[1], Daniel Romero[1,2], 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.

We4G • Photonic-Electronic Memristors for Neuromorphic Applications—Continued

We4H • 8th International Symposium for Optical Interconnect in Data Centres IV—Continued

We4A • Scattering and Nonlinear Effects in Fibers—Continued

We4B • Optical Networks for Sensing and Sensing for Optical Networks—Continued

We4B.5 • 17:00
Component Fault Location in Optical Networks Based on Attention Mechanism with Monitoring Data, Chuidian Zeng[1], Jiawei Zhang[1], Ruikun Wang[1], Bojun Zhang[1], Yuefeng Ji[1]; *[1]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.

We4B.6 • 17:15
Decision Trees for Event Signature Classification on Fiber Optic Cables in Quaternion Coordinates, Essen Dossev[2,1], Petar Djukic[1], Christine Tremblay[2]; *[1]Ciena, Canada; [2]Ecole de technologie superieure, 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 aggregates sufficed to produced 98.8% event classification accuracy.

We4C • Digital Signal Processing for Novel Applications—Continued

We4C.5 • 17:00 Invited
Simultaneuous Sensing and Communication in Optical Fibers, Yue-Kai Huang[1], Ezra Ip[1], Junqiang Hu[1], Ming-Fang Huang[1], Fatih Yaman[1], Ting Wang[1], Glenn Wellbrock[2], Tiejun Xia[2], Koji Asahi[3], Yoshiaki Aono[3]; *[1]NEC Laboratories America Inc., USA; [2]Verizon, USA; [3]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.

We4D • Wide-band Technologies and Transmission—Continued

We4D.6 • 17:00
Multiple Beat-Noise Suppression in Polarization-Multiplexed Pump Light for Forward-Pumped Raman Amplifier, Hiroto Kawakami[1], Takayuki Kobayashi[1], Yoshiaki Kisaka[1]; *[1]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.

17:30–19:00
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.

17:30–19:00 We5 • Joint Poster Session II, *Foyer 2nd Floor*

We4E • Silicon Photonics—Continued

We4F • Satellite Based Optical Freespace Communication II—Continued

We4G • Photonic-Electronic Memristors for Neuromorphic Applications—Continued

We4H • 8th International Symposium for Optical Interconnect in Data Centres IV—Continued

We4E.5 • 17:00
Integrated Microwave Photonic Phase Shifter With Ultrahigh Dynamic Range, Kaixuan Ye[1], Gaojian Liu[1], Okky Daulay[1], Marcel Hoekman[2], Edwin Klein[2], Chris Roeloffzen[2], David Marpaung[1]; *[1]Universiteit Twente, Netherlands; [2]LioniX 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•Hz $^{4/5}$.

We4E.6 • 17:15 ★ Highly Scored
Slice-Less Optical Arbitrary Waveform Measurement (OAWM) on a Silicon Photonic Chip, Daniel Drayss[1,3], Dengyang Fang[1], Christoph Füllner[1], Artem Kuzmin[2,1], Wolfgang Freude[1], Sebastian Randel[1], Christian Koos[1,3]; *[1]Inst. of Photonics and Quantum Electronics (IPQ), Karlsruher Institut fur Technologie, Germany; [2]Laboratory for Applications of Synchrotron Radiation, Karlsruher Institut fur Technologie, Germany; [3]Inst. of Microstructure Technology (IMT), Karlsruher Institut fur Technologie, 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.

17:30–19:00 We5 • Joint Poster Session II, *Foyer 2nd Floor*

08:00–13:30 Registration, *Entrance Hall 1*

08:45–10:00
Th1A • Novel Fiber Fabrication Methods
Presider: Marianne Bigot; Prysmian Group, France

Th1A.1 • 08:45
Simple Multi-Core Fiber Fabrication Method, Pierre Sillard[1], Jean-Baptiste Trinel[1], Alain Giuliani[1], Dimitri Vanhuyse[1], Maryna Kudinova[1], Frank Achten[1]; [1]*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.

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.

08:30–10:15
Th1C • Novel Equalization Techniques
Presider: Sebastian Randel; Karlsruher Institut für Technologie, Germany

Th1C.1 • 08:30 Invited
Nonlinear Component Equalization: A Comparison of Deep Neural Networks and Volterra Series, Maximilian Schaedler[1], Georg Böcherer[1], Francesca Diedolo[2], Stefano Calabrò[1]; [1]*Huawei Munich Research Center, Germany;* [2]*Technische Universitat Munchen, Germany*. Coherent optical transmission systems suffer from distortions induced by nonlinear components. As a countermeasure, Volterra equalizers and deep neural networks have attracted growing attention. In this paper, optimal objectives to maximize achievable rates as well as performance and complexity aspects are discussed.

08:30–10:15
Th1D • SDM Transmission and Monitoring Systems
Presider: Takayuki Kobayashi; NTT Network Innovation Laboratories, Japan

Th1D.1 • 08:30 Invited
Digital Longitudinal Monitoring of Optical Transmission Link, Takeo Sasai[1]; [1]*NTT Corporation, Japan*. We review the advancements in Rx DSP-based transmission-link monitoring methods, which reveal fiber-longitudinal distributions of various physical parameters (e.g., signal power profile, gain spectra, and filter responses) along a multi-span link without analog testing instruments. We also discuss the comparison of power profile estimation methods.

08:00–13:30 Registration, *Entrance Hall 1*

08:30–10:15
Th1E • High-speed Transmitter Devices
Presider: Helene Debregeas; Almae Technologies, France

Th1E.1 • 08:30 Invited

Integrated Silicon Photonic Transceiver Chips for High Bandwidth Density and Energy-Efficient Optical I/O, Haisheng Rong[1]; [1]*Intel Corporation, USA.* Silicon photonics is one of the most promising technologies to address the ever-increasing bandwidth demands on optical interconnects. This talk will focus on high-speed silicon photonic transceivers with integrated lasers, silicon modulators, photodetectors, and CMOS electronic drivers and receivers for energy efficient optical I/O applications.

08:30–10:15
Th1F • Novel PICs and Applications
Presider: Daniel Kuchta; IBM TJ Watson Research Center, USA

Th1F.1 • 08:30 Tutorial

FMCW LiDAR Incorporating Slow-Light Grating Beam Scanners, Toshihiko Baba[1]; [1]*Yokohama National Univ., Japan.* 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.

08:30–10:15
Th1G • Quantum Communication
Presider: Hannes Hübel, Austrian Institute of Technology, Austria

Th1G.1 • 08:30

Countering Detector Manipulation Attacks in Quantum Communication Through Detector Self-Testing, Lijiong Shen[1], Christian Kurtsiefer[1]; [1]*National Univ. of Singapore, Singapore.* Detector manipulation attacks are the most critical vulnerabilities in practical quantum key distribution systems. We present a self-testing method of photodetectors to reveal manipulation by anything but single photon-level signals, which does not rely on specific assumptions about the detection or manipulation mechanism.

Th1G.2 • 08:45 ★ Highly Scored

Towards a European Quantum Network, Domenico Ribezzo[7], Mujtaba Zahidy[1], Ilaria Vagniluca[2], Nicola Biagi[2], Saverio Francesconi[2], Tommaso Occhipinti[2], Leif K. Oxenløwe[1], Martin Lončarić[3], Ivan Cvitić[4], Mario Stipčević[3], Ziga Pušavec[5], Rainer Kaltenbaek[5], Anton Ramšak[5], Francesco Cesa[6], Giorgio Giorgetti[8], Francesco Scazza[6], Angelo Bassi[6], Paolo De Natale[7], Francesco Saverio Cataliotti[7], Massimo Inguscio[9], Davide Bacco[2], Alessandro Zavatta[2]; [1]*CoE SPOC, Danmarks Tekniske Universitet, Denmark;* [2]*QTI SRL, Italy;* [3]*Centre of Excellence for Advanced Materials and Sensing Devices, Institut Ruder Boskovic, Croatia;* [4]*Department of Information and Communication Traffic, Sveuciliste u Zagrebu Fakultet prometnih znanosti, Croatia;* [5]*Univerza v Ljubljani Fakulteta za matematiko in fiziko, Slovenia;* [6]*Universita degli Studi di Trieste Dipartimento di Fisica, Italy;* [7]*Istituto Nazionale di Ottica Consiglio Nazionale delle Ricerche, Italy;* [8]*ICT service area, università degli studi di trieste, Italy;* [9]*Universita Campus Bio-Medico di Roma Facolta Dipartimentale di Ingegneria, Italy.* Already deployed optical fibers have been utilized to realize the first quantum network connecting three countries. The cities of Trieste (Italy), Rijeka (Croatia) and Ljubljana (Slovenia) have exchanged quantum keys with a rate up to 3.13 kps, realizing quantum key distribution in a real-world scenario.

08:30–10:15
Th1H • Prospects for the Usage of Millimeter Wave Bands
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

The use of radiations with wavelength from ten to one millimeter, commonly called millimeter waves and corresponding to the radio frequencies in the range 30 – 300 GHz, is often considered as a communication medium.
The increasing bandwidth requirement of new wireless applications 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.

See page 21 of this programme for a list of speakers and topics for this Symposium.

Th1A • Novel Fiber Fabrication Methods—Continued

Th1A.2 • 09:00 Invited

Thermal Sensitivity of Optical Fibres and How to Reduce it, Radan Slavik[1], Eric Numkam Fokoua[1], Zitong Feng[1], Meng Ding[1], Francesco Poletti[1], David Richardson[1]; *[1]Univ. 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.

Th1A.3 • 09:30 Invited

3D Printed Chalcogenide Fibers, Johann Troles[1]; *[1]Universite de Rennes I, 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 fibers manufacturing but also many other chalcogenide glass optical components.

Th1B • Free Space Optical Communication for Terrestrial & Space Applications I—Continued

Th1C • Novel Equalization Techniques—Continued

Th1C.2 • 09:00

Partially Frozen MIMO Processing for Fast Polarisation Tracking, Akira Kawai[1], Masanori Nakamura[1], Minami Takahashi[1], Takayuki Kobayashi[1], Yutaka Miyamoto[1]; *[1]NTT Network Innovation Laboratories, Japan.* We proposed an adaptive equalisation scheme that has both fast polarisation tracking capability and transceiver IQ impairment tolerance based on partial freezing of the multiple-input multiple-output structure. Experimental results showed superior equalisation performance of the scheme to previous ones under polarisation fluctuations exceeding 11 Mrad/s.

Th1C.3 • 09:15

Robust Pilot-Aided Timing Recovery Algorithm for OQAM-Based Digital Multi-Band Systems, Wanzhen Guo[1], Zhaoquan Fan[1], Ziheng Zhang[1], Jiating Luo[2], Bofang Zheng[2], Jian Zhao[1]; *[1]South China Univ. of Technology, China; [2]Huawei Technologies Co Ltd, China.* We propose the first timing recovery algorithm for OQAM-based digital multi-band (DMB) systems where Gardner, Godard and square-Gardner algorithms fail. 320-Gbit/s experiments and simulations show that OQAM-DMB using the proposed algorithm outperforms QAM-DMB using conventional algorithms and is also robust to spectral roll-off and DGD.

Th1C.4 • 09:30

Transfer Function Equalization Enhanced Phase Noise in Generalized Carrier Assisted Differential Detection Receivers, Honglin Ji[2,1], Jingchi Li[3], Xingfeng Li[3], Zhen Wang[3], Ranjith Rajasekharan Unnithan[1], Yikai Su[3], Weisheng Hu[2,3], William Shieh[1]; *[1]The Univ. of Melbourne, Australia; [2]Peng Cheng Laboratory, China; [3]Shanghai Jiao Tong Univ., China.* We analyze the equalization enhanced phase noise (EEPN) 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 EEFN effect could be greatly alleviated when using the transmitter lasers with a large linewidth.

Th1D • SDM Transmission and Monitoring Systems—Continued

Th1D.2 • 09:00

Transoceanic-Class Transmission Over Step-Index Profile Standard Cladding 4-Core Fibre With Bidirectional Transmission Technology, Daiki Soma[1], Shohei Beppu[1], Noboru Yoshikane[1], Takehiro Tsuritani[1]; *[1]KDDI Research, Inc., Japan.* Transoceanic-class multi-core fibre bidirectional transmission is experimentally demonstrated using step-index profile standard cladding 4-core fibres without trench-assisted pure-silica cores for the first time. 4-SDM/16-WDM channels modulated with 24-Gbaud DP-QPSK are successfully transmitted over 7,000 km with no impact of core-to-core crosstalk.

Th1D.3 • 09:15

PDM-16QAM 300-km Transmission Over Installed High-Crosstalk Step-Index Multi-Core Fibre Cable Employing Unreplicated Crosstalk Canceller, Kohki Shibahara[1], Takayoshi Mori[2], Yusuke Yamada[2], Kazuhide Nakajima[2], Yutaka Miyamoto[1]; *[1]NTT Network Innovation Laboratories, Japan; [2]NTT Access Network Service System Laboratories, Japan.* We propose a low-complexity unreplicated crosstalk canceller (UCC) that eliminates inter-channel interference in a weakly-coupled SDM link. Transmission experiment over installed step-index multicore fibre cables verifies that the UCC tripled the achievable transmission reach for PDM-16QAM signals even with inter-core crosstalk accumulation of -5 dB.

Th1D.4 • 09:30

Dependence of Q^2 on Inter-Core Skew and Mode-Dependent Loss in Long-Haul Coupled-Core Multicore Fibre Transmission, Shohei Beppu[1], Daiki Soma[1], Noboru Yoshikane[1], Takehiro Tsuritani[1]; *[1]KDDI Research, Inc., Japan.* We experimentally evaluate the dependence of the Q^2 on inter-core skew and mode-dependent loss in long-haul coupled-core four-core fibre transmission. A skew within less than 200 ps per span is required for 6,020-km transmission. Large Q^2 degradation and fluctuation and are observed due to MDL.

Th1E • High-speed Transmitter Devices—Continued

Th1E.2 • 09:00
Superior Lowest TDECQ (3.3 dB at 106 Gb/s, 4.4 dB at 112 Gb/s) Under PAM-4 Operation at up to 85°C With High Extinction Ratio (4 dB) in 1.3-µm Uncooled Directly Modulated InGaAlAs MQW-BH Lasers, Kouji Nakahara[1], Kazuki Suga[1], Shigenori Hayakawa[1], Masatoshi Arasawa[1], Ryu Washino[1], Takeshi Kitatani[1], Masatoshi Mitaki[1], Hironori Sakamoto[1], Shigehisa Tanaka[1]; *[1]Lumentum, Japan.* The lowest TDECQ values are achieved under PAM-4 operation with 4-dB extinction ratio in improved submicron-ridge-localized-buried-heterostructure DFB lasers at up to 85°C among uncooled DMLs ever reported. The laser can attain transmission over 2-km standard single-mode-fiber with CWDM wavelength.

Th1E.3 • 09:15
420 Gbps PAM8 Operation Using 93 GHz Bandwidth Lumped-Electrode Type EA-DFB Laser at 50°C Beyond 400 Gbps/Lane, Hideaki Asakura[1], Kazuki Nishimura[1], Syunya Yamauchi[1], Yoshihiro Nakai[1], Takanori Suzuki[1], Yoriyoshi Yamaguchi[1], Kentaro Tani[1], Ryosuke Nakajima[1], Kazuhiko Naoe[1]; *[1]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.

Th1E.4 • 09:30
A Low Chirp Electroabsorption Modulated Laser Suitable for 200Gb/s PAM4 CWDM Transmission Over 2km, Xin Chen[1], Richard Cronin[1], Haibo Wang[1], Malcolm Pate[1], Ping Liao[2], Kexin Biang[2], Jialin Zhao[2], Linfeng He[2], Junfeng Liu[2], Eva Repiso[1], David Rogers[1], Chaoyi Wang[1], Graham Berry[1], Xuefeng Liu[1], Bo Zhou[1]; *[1](1) Hisilicon Optoelectronics Co., ltd., Ipswich Research Centre, UK; [2](2) Hisilicon Optoelectronics Co., ltd., Wuhan Research Inst., China.* 200Gb/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.

Th1F • Novel PICs and Applications—Continued

Th1F.2 • 09:30
Low Power Consumption 2D Beam Scanner Integrated With Wavelength Tunable Laser Diode, Yamato Misugi[1], Hideaki Okayama[2], Tomohiro Kita[1]; *[1]Waseda Daigaku Riko Gakujutsuin, Japan; [2]Oki Electric Industry Co. Ltd., Japan.* In this paper, we fabricated a 6 × 1.5 mm^2 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 °.

Th1G • Quantum Communication—Continued

Th1G.3 • 09:00
Demonstration of 17λ × 10 Gb/s C-Band Classical / DV-QKD Co-Existence Over Hollow-Core Fiber Link, Florian Honz[1], Florian Prawits[1], Obada Alia[2], Hesham Sakr[3], Thomas Bradley[3], Cong Zhang[3], Radan Slavik[3], Francesco Poletti[3], George Kanellos[2], Reza Nejabati[2], Philip Walther[4], Dimitra Simeonidou[2], Hannes Hübel[1], Bernhard Schrenk[1]; *[1]Austrian Inst. of Technology GmbH, Austria; [2]Univ. of Bristol, UK; [3]Univ. of Southampton Optoelectronics Research Centre, UK; [4]Universitat Wien Fakultat fur Physik, Austria.* We successfully integrate coherent one-way QKD at 1538 nm in a 7.7 km long hollow-core fiber link with 17 EDFA-boosted C-band data channels from 1540.56 to 1558.17 nm, aggregating a power of 11 dBm. QKD operation proves successful despite the wideband layout of classical channels.

Th1G.4 • 09:15
Distributing Polarization Entangled Photon Pairs With High Rate Over Long Distance Through Standard Telecommunication Fiber, Lijiong Shen[1], Chang Hoong Chow[1], Justin Yu Xiang Peh[1], Xi Jie Yeo[1], Peng Kian Tan[1], Christian Kurtsiefer[1,2]; *[1]Centre for Quantum Technologies, National Univ. of Singapore, Singapore; [2]Department of Physics, National Univ. of Singapore, Singapore.* Moderate photon pair rates limit fiber-based entanglement distribution. A bright non-degenerate photon pair source, designed for high idler photon detection efficiency on single-photon avalanche photodiodes and low signal photon dispersion in optical fiber, enables high pair rates even after propagating through 50km standard telecommunication fiber.

Th1G.5 • 09:30 ★ Highly Scored
Continuous-Variable Quantum Key Distribution Over 60 km Optical Fiber With Real Local Oscillator, Adnan Hajomer[1], Hossein Mani[1], Nitin Jain[1], Hou-Man Chin[2,1], Ulrik Andersen[1], Tobias Gehring[1]; *[1]Physics, Danmarks Tekniske Universitet, Denmark; [2]Photonics, Danmarks Tekniske Universitet, Denmark.* We report the first continuous-variable quantum key distribution experiment that enables the generation of secure key over a 60 km fiber channel with locally generated local oscillator. This is achieved by controlling the excess noise using machine learning for phase noise compensation while operating the system at a low modulation variance.

Th1H • Prospects for the Usage of Millimeter Wave Bands—Continued

Th1A • Novel Fiber Fabrication Methods—Continued

Th1B • Free Space Optical Communication for Terrestrial & Space Applications I—Continued

Th1C • Novel Equalization Techniques—Continued

Th1C.5 • 09:45 ★ Highly Scored

Spiking Neural Network Equalization on Neuromorphic Hardware for IM/DD Optical Communication, Elias Arnold[1], Georg Böcherer[2], Eric Mueller[1], Philipp Spilger[1], Johannes Schemmel[1], Stefano Calabrò[2], Maxim Kuschnerov[2]; [1]*Ruprecht Karls Universitat Heidelberg Kirchhoff-Institut fur Physik, Germany;* [2]*Huawei 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 Equaliser, Stephen L. Murphy[1], Fariba Jamali[1], Paul D. Townsend[1], Cleitus Antony[1]; [1]*Tyndall National Inst., Ireland.* We investigate parallel multi-symbol equalisation scheme for 100Gb/s/λ 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 3.8×10^{-3} using a receiver with two gain settings.

Th1D • SDM Transmission and Monitoring Systems—Continued

Th1D.5 • 09:45 Invited

MCF in Cable and Transmission Trials, Hitoshi Takeshita[1]; [1]*Advanced Network Research Laboratories, Nihon Denki Kabushiki Kaisha, Japan.* A prototype of submarine cable with 4-core uncoupled MCF was demonstrated. Through 5,350-km transmission trials using this MCF, no performance degradation due to the cabling process was observed. Also, reduction in the number of fan-in fan-outs in the transmission line contributed to improving transmission performance.

10:15–10:45 Coffee Break, *Foyer 2nd Floor*

Boston

Th1E • High-speed Transmitter Devices—Continued

Th1E.5 • 09:45
200 Gb/s Uncooled EML With Single MQW Layer Stack Design, Michael A. Theurer[1], Christoph Kottke[1], Ronald Freund[1,2], Felix Ganzer[1], Patrick Runge[1], Martin Moehrle[1], Ute Troppenz[1], Ariane Sigmund[1], Martin Schell[1,2]; *[1]Fraunhofer Heinrich Hertz Inst., Germany; [2]Technische Universitat 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 Dubrovina[1], Elena Duran[1], Hélène Debregeas[1], Ricardo Rosales[2], François Lelarge[1], Romain Brenot[3]; *[1]Almae Technologies, France; [2]Huawei Technologies Munich, Germany; [3]Huawei 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.

Shanghai

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 Xiao[1], Weigang Ge[1], Siyuan Li[1], Liang Ning[1], Maliang Liu[1]; *[1]Xidian 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 Tanomura[1], Rui Tang[1], Go Soma[1], Shota Ishimura[2], Takuo Tanemura[1], Yoshiaki Nakano[1]; *[1]the Univ. of Tokyo, Japan; [2]KDDI 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.

Kairo

Th1G • Quantum Communication—Continued

Th1G.6 • 09:45 Invited
Microwave-Optical Transduction With Integrated Gallium Phosphide Devices, Simon Hönl[1], Youri Popoff[1], Daniele Caimi[1], Alberto Beccari[2], Tobias Kippenberg[2], Paul Seidler[1]; *[1]IBM Research GmbH, Switzerland; [2]Ecole 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 $g_0/2\pi \approx 300$ kHz.

Delhi

Th1H • Prospects for the Usage of Millimeter Wave Bands—Continued

10:15–10:45 Coffee Break, *Foyer 2nd Floor*

Samarkand + Osaka

10:45–12:30
Th2A • Single Core and Multicore Fiber Amplifiers
Presider: Seongwoo Yoo, Nanyang Technological University, China

Th2A.1 • 10:45
195-nm Multi-Band Amplifier Enabled by Bismuth-Doped Fiber and Discrete Raman Amplification, Aleksandr I. Donodin[1], Prarim Hazarika[1], Mingming Tan[1], Vladislav Dvoyrin[1], Mohammed Patel[1], Ian Phillips[1], Paul Harper[1], Sergei Turistyn[1], Wladek Forysiak[1]; *[1]Aston Univ., UK.* 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 195- nm 30 GBaud PM-16-QAM signal amplified with 15 dB gain and 6 dB NF.

Th2A.2 • 11:00 ★ Highly Scored
Extending L-Band Gain to 1625 nm Using Er^{3+}:Yb^{3+} Co-Doped Silica Fibre Pumped by 1480 nm Laser Diodes, Ziwei Zhai[2], Jayanta K. Sahu[1]; *[2]Univ. of Southampton Zepler Inst. for Photonics and Nanoelectronics, UK.* We report a high-concentration Er-Yb 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 -0.065dB/°C temperature-dependent-gain coefficient. Also, a 10dB single-channel small-signal gain was obtained at 1625nm.

Th2A.3 • 11:15
1760 nm Multi-Watt Broadband PM CW and Pulsed Tm-Doped Fibre Amplifier, Wiktor T. Walasik[1], Robert E. Tench[1], Gustavo Rivas[1], Jean-Marc Delavaux[1], Ian Farley[2]; *[1]CYBEL LLC, USA; [2]Eblana 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 20W 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.

Singapore

10:45–12:30
Th2B • Free Space Optical Communication for Terrestrial & Space Applications II
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.

Sydney

10:45–12:30
Th2C • High Baud Rate Transmission
Presider: Sander Wahls; Technische Universiteit Delft, Netherlands

Th2C.1 • 10:45 Invited
Performance Analysis of Recurrent Neural Network-Based Digital Pre-Distortion for Optical Coherent Transmission, Vinod Bajaj[2,1], Vahid Aref[1], Sander Wahls[2]; *[1]Nokia Solutions and Networks GmbH und Co KG Stuttgart, Germany; [2]Technische Universiteit 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
Digital Compensation for SOA-Induced Nonlinear Distortion in Ultra-High Symbol Rate Signals, Fukutaro Hamaoka[1], Masanori Nakamura[1], Takeo Sasai[1], Takayuki Kobayashi[1], Munehiko Nagatani[1,2], Hitoshi Wakita[2], Hiroshi Yamazaki[1,2], Yoshihiro Ogiso[2,3], Yutaka Miyamoto[1]; *[1]NTT Network Innovation Laboratories, Japan; [2]NTT Device Technology Laboratories, Japan; [3]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.

Rio

10:45–12:30
Th2D • Intra-data Centre Networks
Presider: Stephan Pachnicke; Christian-Albrechts Universität zu Kiel, Germany

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

Boston

10:45–12:30
Th2E • Photodiodes and Photodetectors
Presider: Jean Teissier; II-VI Laser Enterprise, Switzerland

Th2E.1 • 10:45 Invited
Avalanche Photodiode With High Dynamic Range, High Speed and Low Noise, Hektor T. Meier[1], Alberto Ciarrocchi[1], Maria Hämmerli[1], Wei Quan[1]; *[1]Albis Optoelectronics AG, Switzerland.* This paper reviews recent advances and novel applications of state-of-the-art, III-V avalanche photodiodes. We demonstrate a record sensitivity of -34.5 dBm and -27 dBm, for 10 Gb/s and 25 Gb/s APDs respectively, with a high optical damage threshold above +6 dBm.

Th2E.2 • 11:15
200Gb/s per Lane Ge/Si Waveguide Avalanche Photodiode, Mengyuan Huang[1], Kiyoung Lee[1], Kelly Magruder[1], Olufemi Dosunmu[1], Ryan Haislmaier[1], Hao-Hsiang Liao[1], Wei Qian[1], Paul Martin[1], Jeremy Hicks[1], Pari Patel[1], Carsten Brandt[1], Ansheng Liu[1]; *[1]Intel Corp, USA.* We demonstrate a waveguide-integrated Ge/Si APD with 3dB bandwidth of 52.2GHz at gain of 3.8 and 45.8GHz at gain of 6. This device also shows a large dynamic range with responsivity changes 1.6-3.5A/W. This high-performance device is suitable for various 200Gb/s per lane applications.

Shanghai

10:45–12:30
Th2F • Non-Linear Devices and Packaging
Presider: Segolene Olivier; CEA-LETI, France

Th2F.1 • 10:45
Time-Continuous Travelling-Wave Optical Parametric Amplification in a Photonic Circuit, Johann Riemensberger[1], Nikolai Kusnetzov[1,2], Junqiu Liu[1], Jijun He[1], Rui N. Wang[1], Tobias Kippenberg[1]; *[1]Ecole Polytechnique Federale de Lausanne, Switzerland; [2]Russian Quantum Center, Russian Federation.* We demonstrate a traveling wave parametric amplifier in a photonic Si_3N_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 and Output Wavelengths Using PPLN-Based Polarization-Diversity Dual-Stage SFG-DFG Process, Takeshi Umeki[1,2], Takushi Kazama[1,2], Shimpei Shimizu[2], Takahiro Kashiwazaki[1], Koji Enbutsu[1], Takayuki Kobayashi[2], Yutaka Miyamoto[2], Kei Watanabe[1,2]; *[1]NTT Device Technology Laboratories, NTT Corporation, Japan; [2]NTT Network Innovation Laboratories, NTT Corporation, Japan.* We propose a modulation-format-independent tunable wavelength convertor 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[2], Gregor Ronniger[2], Carsten Schmidt-Langhorst[2], Robert Elschner[2], Md Mahasin Khan[2], Hidenobu Muranaka[3], Tomoyuki Kato[4], Shun Okada[3], Tsuyoshi Yamamoto[3], Yu Tanaka[3], Takashi Hoshida[3], Colja Schubert[2], Ronald Freund[2,1]; *[1]Technische Universität Berlin, Germany; [2]Fraunhofer-Institut fur Nachrichtentechnik Heinrich-Hertz-Institut HHI, Germany; [3]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 SSMF link.

Kairo

10:45–12:30
Th2G • Quantum Photonics
Presider: Steve Lecomte, CSEM, Switzerland

Th2G.1 • 10:45 ★ Highly Scored
Versatile, All-Diamond Scanning Probes for High-Performance Nanoscale Magnetometry, Gediminas Seniutinas[1], Marcelo Gonzalez[1], Brendan Shields[2], Felipe Favaro de Oliveira[1], Patrick Maletinsky[2,1]; *[1]Qnami AG, Switzerland; [2]Universitat 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 ★ Highly Scored
Single-Photon Storage in a Ground-State Vapor Cell Quantum Memory, Gianni C. Buser[1], Roberto Mottola[1], Björn Cotting[1], Janik Wolters[2,3], Philipp Treutlein[1]; *[1]Departement Physik, Universitat Basel, Switzerland; [2]Inst. of Optical Sensor Systems, Deutsches Zentrum fur Luft- und Raumfahrt eV, Germany; [3]Institut für Optik und Atomare Physik, Technische Universitat 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.

Th2G.3 • 11:15 Invited
Entanglement of Remote Trapped Ions, Tracy Northup[1]; *[1]Inst. for Experimental Physics, Universitat Innsbruck, Austria.* We have demonstrated an elementary quantum network in which two $^{40}Ca^+$ ions in separate buildings are entangled; each ion is coupled to a cavity, and the nodes are linked by a 510(2) m fiber. Fidelities as high as (89+2-6)% are determined via quantum state tomography.

Delhi

10:45–12:30
Th2H • Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO_2)
Organisers: Hélène Debrégeas, Almae Technologies, France
Lucas Soldano, POET Technologies, USA

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.

Th2A • Single Core and Multicore Fiber Amplifiers—Continued

Th2A.4 • 11:30
L-Band 19-Core Erbium Doped Fibre Amplifier With Power Consumption of 1.2 W/Core for 20 dBm/Core Output, Shigehiro Takasaka[1], Koichi Maeda[1], Ryuichi Sugizaki[1], Yoshihiro Arashitani[1]; [1]*Furukawa Electric Co., Ltd., Japan*. We fabricate a double cladding uncoupled 19-core EDF with cladding diameter of 166 mm. We confirm that power consumption of a cladding pumped L-band 19-core EDFA with 20 dBm/core output is as small as 1.2 W/core under 11.2W laser diode output for the cladding pump.

Th2A.5 • 11:45 ★ Highly Scored
FIFO-Less Core-Pumped Multicore Fibre Amplifier With Fibre Bragg Grating Based Gain Flattening Filter, Yuta Wakayama[1], Noboru Yoshikane[1], Takehiro Tsuritani[1]; [1]*KDDI Research, Japan*. A multicore fibre Bragg grating is firstly employed as a gain flattening filter in a multicore erbium-doped fibre amplifier. The gain spectra are successfully flattened within ±0.7 dB for all cores.

Th2A.6 • 12:00
Improvement of the Energy Efficiency of Cladding Pumped Multicore EDFA Employing Bidirectional Pumping and Control, Hitoshi Takeshita[1], Yusuke Shimomura[1], Kohei Hosokawa[1], Emmanuel Le Taillandier de Gabory[1]; [1]*Nihon Denki Kabushiki Kaisha, Japan.* Cladding pump optical power ratio between forward and backward was controlled to realize the highest power efficiency. Considering output wavelength channel power equalization, we confirmed 24 % pump optical power reduction at 8 W total pump optical power for 0.8 dB penalty of noise figure.

Th2B • Free Space Optical Communication for Terrestrial & Space Applications II—Continued

Th2C • High Baud Rate Transmission—Continued

Th2C.3 • 11:30
WSS Filtering Penalties With Bandwidth-Variable Transceivers: on the Debate Between Single- and Multi-Carrier, Pedro Loureiro[1,2], Abel L. Riesgo[3], Sami Mumtaz[3], Manuel Neves[1,2], Dylan Le Gac[3], Trung-Hien Nguyen[3], Yann Frignac[3], Paulo P. Monteiro[1,2], Gabriel Charlet[3], Stefanos Dris[3], Fernando Guiomar[1]; [1]*Instituto de Telecomunicacoes, Portugal;* [2]*Universidade de Aveiro, Portugal;* [3]*Huawei Technologies France SAS, France*. We experimentally compare the WSS filtering tolerance of single-carrier (SC) and digital sub- carrier multiplexing (DSCM) at 95–105 Gbaud. Whereas DSCM tends to be advantageous when using ultra-high baudrates, the two modulation options yield similar performance if the baudrate is optimized.

Th2C.4 • 11:45
Simplified Phase Retrieval Receiver Employing Transmission Fiber for Alternative Projection, Hanzi Huang[2,1], Haoshuo Chen[2], Nicolas K. Fontaine[2], Yingxiong Song[1], Mikael Mazur[2], Lauren Dallachiesa[2], Dora V. Veen[2], Vincent Houtsma[2], Roland Ryf[2], David T. Neilson[2]; [1]*Shanghai Univ., China;* [2]*Nokia Bell Labs, USA*. We simplify phase retrieval receiver by directly using transmission fiber as a dispersive element. Performance enhancement is achieved by employing constant modulus constraint of 40-Gbaud QPSK and 8-PSK signal after 40-km single-mode fiber transmission.

Th2C.5 • 12:00 Invited
Machine Learning and Neuromorphic Computing Approaches for the Mitigation of Transmission Impairments in High Baud Rate Transmission System, Adonis Bogris[1], Kostas Sozos[1], Stavros Deligiannidis[1], George C. Sarantoglou[2], Charis Mesaritakis[2]; [1]*Univ. of West Attica, Greece;* [2]*Panepistemio Aigaiou, Greece*. We review our recent work in machine learning and neuromorphic processing for the mitigation of transmission impairments at very high baud rates. Bidirectional recurrent neural networks and neuromorphic recurrent spectral slicers emerge as promising solutions for mid-term deployment in long-haul and short-reach communication systems respectively.

Th2D • Intra-data Centre Networks—Continued

Th2D.2 • 11:45 ★ Highly Scored
12.8 Tb/s SDM Optical Interconnect for a Spine-Leaf Datacenter Network With Spatial Channel Connectivity, Ruben S. Luis[1], Benjamin J. Puttnam[1], Georg Rademacher[1], Satoshi Shinada[1], Tetsuya Hayashi[2], Tetsuya Nakanishi[2], Yuki Saito[2], Tetsu Morishima[2], Hideaki Furukawa[1]; [1]*National Inst of Information & Comm Tech, Japan;* [2]*Optical Communications Laboratory, Sumitomo Electric Industries Ltd, Japan*. We experimentally demonstrate 12.8 Tb/s 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 Tb/s interconnects and the use of low-loss optical cross-connects for spatial channel connectivity.

Th2D.3 • 12:00
System Performance Assessment of an Optical Wireless Data Center Network Based on Photonic Integrated Multicast Switch, Shaojuan Zhang[1], Netsanet Tessema[1], Rafael Kraemer[1], Xuwei Xue[1], Henrique Freire Santana[1], Eduward Tangdiongga[1], Nicola Calabretta[1]; [1]*Technische Universiteit Eindhoven, Netherlands*. We propose an OW-DCN using a nanoseconds photonic integrated SOA based multicast switch chip to realize fast optical packet switching. System experiments with a fabricated 4×2 switch chip in a 4×4 rack OW-DCN show a WDM multicast switch operation at 50Gb/s with <1.5dB power penalty.

Th2E • Photodiodes and Photodetectors—Continued

Th2E.3 • 11:30
UTC Photodiodes on Silicon Nitride Enabling 100 Gbit/s Terahertz Links at 300 GHz, Dennis Maes[1], Sam Lemey[1], Gunther Roelkens[1], Mohammed Zaknoune[2], Vanessa Avramovic[2], Etienne Okada[2], Pascal Szriftgiser[3], Emilien Peytavit[2], Guillaume Ducournau[2], Bart Kuyken[1]; *[1]Ghent Univ., Belgium; [2]Institut d'Electronique de Microelectronique et de Nanotechnologie, France; [3]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.

Th2E.4 • 11:45
High-Bandwidth Photodiodes on Silicon Nitride Supporting Net Bitrates in Excess of 350 Gbit/s., Dennis Maes[1], Qian Hu[2], Robert Borkowski[2], Yannick Lefevre[3], Gunther Roelkens[1], Sam Lemey[1], Emilien Peytavit[4], Bart Kuyken[1]; *[1]Ghent Univ., Belgium; [2]Nokia Bell Labs, USA; [3]Nokia Bell Labs Antwerp, Belgium; [4]Institut d'Electronique de Microelectronique et de Nanotechnologie, France.* Silicon-nitride-based integrated photonic platforms currently lack fast photodiodes, limiting its adoption for high-speed optical transceivers. We show uni-traveling-carrier (UTC) photodiodes heterogeneously integrated by means of micro-transfer-printing and demonstrate their excellent bandwidth performance achieving net bit rates in excess of 350 Gbit/s.

Th2E.5 • 12:00 ★ Highly Scored
Single Lane Beyond 400 Gbit/s Optical Direct Detection Based on a Sidewall-Doped Ge-Si Photodetector, Xiao Hu[1,2], Dingyi Wu[1], Xi Xiao[2,1], Lei Wang[1,2]; *[1]NOEIC, China; [2]CICT, China.* We present a photodetector in which the sloped sidewalls of germanium are carefully doped. The 3-dB bandwidth > 55 GHz and responsivity of 1 A/W are demonstrated. Single lane direct detection of record-high speed 290 Gbit/s PAM-4 and 408 Gbit/s PAM-8 optical signals are achieved.

Th2F • Non-Linear Devices and Packaging—Continued

Th2F.4 • 11:30
800G DR8 Transceiver Based on Thin-Film Lithium Niobate Photonic Integrated Circuits, Heng Li[1], Lane Luo[2], Quanan Chen[3], Jin Yu[3], Rui Huang[2], Jiangen He[2], Yongqian Tang[1], Allen Zheng[2], Zuxin Zhong[3], Celia Lei[2], Hua Liu[3], Xiaohan Li[3], Lirong Huang[1], Qiaoyin Lu[1], Mingzhi Lu[3], Weihua Guo[1,3]; *[1]Huazhong Univ. of Science and Technology, China; [2]Applied Optoelectronics Inc, USA; [3]Ningbo Ori-chip Optoelectronics Technology LTD, India.* We demonstrate a fully functional 800G DR8 OSFP transceiver based on thin-film lithium niobate photonic integrated circuits. The transceiver achieves TDECQ below 2.5 dB, and ER above 5 dB. Total transceiver power consumption is achieved around 14.2 Watts at 70 degree Celsius ambient temperature.

Th2F.5 • 11:45
A Monolithically Integrated Tunable Comb Source and Filter, John McCarthy[1], Maryam Shayesteh[2], Mohamad Dernaika[1], Frank Peters[1]; *[1]Tyndall National Inst., Ireland; [2]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.

Th2F.6 • 12:00
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 Goh[1], Baochang Xu[2], Yu Zhang[2], Chun Fei Siah[2], Bo Zhao[1], Rappl Sebastian[3], James Lee[1], Suresh Venkatesan[1], Aaron Thean[2], Yeow Kheng Lim[2]; *[1]POET Technologies, Singapore; [2]National Univ. of Singapore, Singapore; [3]ASM 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.

Th2G • Quantum Photonics—Continued

Th2G.4 • 11:45 Invited
Cooperative Quantum Light Emission From Lead Halide Perovskites, Gabriele Raino[2,3], Michael A. Becker[1], Etsuki Kobiyama[1], Chenglian Zhu[2,3], Ihor Cherniukh[2,3], Taras Sekh[2,3], Franziska Krieg[2,3], Yuliia Berezovska[2,3], Maryna I. Bodnarchuck[2,3], Maksym V. Kovalenko[2,3], Rainer F. Mahrt[1], Thilo Stöferle[1]; *[1]IBM Research GmbH, Switzerland; [2]Chemistry and Applied Bioscience, Eidgenossische Technische Hochschule Zurich, Switzerland; [3]Laboratory for Thin Films and Photovoltaics, Eidgenössische Materialprüfungs- und Forschungsanstalt Dübendorf, Switzerland.* We use colloidal lead halide perovskite nanocrystals as highly luminescent building blocks for complex superlattices. These assemblies give rise to spontaneous coherent coupling between the constituent quantum dots and enable collective superfluorescent light emission bursts.

Th2H • Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO_2)—Continued

Samarkand + Osaka	Singapore	Sydney	Rio
Th2A • Single Core and Multicore Fiber Amplifiers—Continued	**Th2B • Free Space Optical Communication for Terrestrial & Space Applications II—Continued**	**Th2C • High Baud Rate Transmission—Continued**	**Th2D • Intra-data Centre Networks—Continued**
Th2A.7 • 12:15 **Core-to-Cladding Ratio-Optimized L-Band Coupled 12-Core Fibre Amplifier With the Highest Power Conversion Efficiency,** Taiji Sakamoto[1], Ryota Imada[1], Shinichi Aozasa[1], Kazuhide Nakajima[1]; [1]*NTT 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-Si_3N_4 Tunable Laser Source for Short-Reach Systems,** Lakshmi Narayanan Venkatasubramani[1], Devika Dass[1], Amol Delmade[1], Chris Roeloffzen[2], Douwe Geuzebroek[2], Liam P. Barry[1]; [1]*Dublin City Univ., Ireland;* [2]*LioniX 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-Si_3N_4 laser source for short-reach application. We successfully show the performance is within the standard FEC limits.
13:30–15:00 **Th3A • Postdeadline Session III** *Presider: Rachel Grange, ETH Zurich, Switzerland*	**13:30–15:00** **Th3B • Postdeadline Session I** *Presider: Bert Offrein, IBM Research Zurich, Switzerland*	**13:30–15:00** **Th3C • Postdeadline Session II** *Presider: Hans Limberger, EPFL, Switzerland*	**13:30–15:00** **Th3D • Postdeadline Session IV** *Presider: Niels Quack, University of Sydney, Australia*
	15:15–16:00 **Closing Ceremony** *Presiders: Juerg Leuthold, ETH Zurich, Switzerland* *Christoph Harder, Swissphotonics, Switzerland*		

Th2E • Photodiodes and Photodetectors—Continued

Th2E.6 • 12:15
Photodetectors for Classic and Quantum Communication With 39 GHz Bandwidth and 66% Quantum Efficiency, Tobias Beckerwerth[1], Trung Thanh Tran[1], Sven Mutschall[1], Patrick Runge[1], Martin Schell[1,2]; *[1]Fraunhofer Heinrich Hertz Inst., Germany; [2]Physics, Technische Universitat Berlin Fakultat 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 • Non-Linear Devices and Packaging—Continued

Th2F.7 • 12:15
Demonstration of a Single-Mode Expanded-Beam Connectorized Module for Photonic Integrated Circuits, Kamil Gradkowski[1], David Stegall[2], David Mackey[3], Alan Naughton[3], Terry Smith[4], Peter O'Brien[1]; *[1]Photonics Packaging, Tyndall National Inst., Ireland; [2]CRML, Physical Sciences, 3M, USA; [3]mBryonics, Ireland; [4]International 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.

Th2G • Quantum Photonics—Continued

Th2H • Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO_2)—Continued

Poster Sessions

Foyer 2nd Floor

17:30–19:00
Tu5 • Joint Poster Session I

SC1 – Novel Fibres, Fibre Devices & Amplifiers – Posters

Tu5.1
2-Dimensional Low-Profile Fiber Coupler for Co-Packaged Optics, Tsutaru Kumagai[1], Haruki Kitao[1], Tetsuya Nakanishi[1]; *[1]Sumitomo Electric Industries, Ltd., Japan.* 2-dimensional low-profile fiber coupler (2D-LPC) with 64-SMFs and 8-PMFs is demonstrated for co-packaged optics. The fabricated 2D-LPC shows high density of 24 fibers/mm, total height of 5.5 mm, low insertion loss of < 0.5 dB, and high polarization extinction ratio of > 20 dB.

Tu5.2
Simulations and Measurements of Spontaneously Initiated Brillouin Scattering in Optical Fibers, Mads H. Vandborg[3], Karsten Rottwitt[3], Lars S. Rishøj[3], Jesper B. Christensen[1], Lars Grüner-Nielsen[3,2], Neethu M. Mathew[3]; *[1]Danmarks Nationale Metrologiinstitut, Denmark; [2]Danish Optical Fiber Innovation, Denmark; [3]Danmarks Tekniske Universitet, Denmark.* Using a stochastic model, we simulate the spontaneously initiated Brillouin scattering in a single-mode optical fiber. In comparing our model with measurements, we find that the model successfully reproduces both the characteristics of the stochastic time traces and the resulting spectra.

Tu5.3
Linewidth, RIN, and Low-Frequency Noise Measurements of a 300 mW 2039 nm PM DFB FBG Laser Pumped with a Semiconductor Laser and a Fibre Laser, Wiktor T. Walasik[1], Shivaraman Asoda[1], Robert E. Tench[1], Jean-Marc Delavaux[1], Emmanuel Pinsard[2]; *[1]CYBEL LLC, USA; [2]iXblue, France.* We demonstrate the performance of a 2039 nm PM DFB FBG laser pumped with two types of 1.5 µm pumps. We obtained output signal powers >330 mW, with slope efficiency >16%, and a single-mode operation with OSNR >65 dB/0.1 nm. Laser linewidth <12 kHz and the RIN<-117 dB/Hz were measured.

Tu5.4
Single-Mode Expanded Beam MT Connector with Angled Lens Array for Improved Optical Performance, Michael Kadar-Kallen[1], Dan Kurtz[1], Sharon Lutz[1], Dirk Schoellner[1], Ke Wang[1], Davide Fortusini[2], Robert Modavis[2]; *[1]US Conec Ltd, USA; [2]Corning Incorporated, USA.* A single-mode 16 fiber expanded beam ferrule compatible with standard MT based connectors designed to meet data center optical link requirements is demonstrated. Optical performance including environmental exposure and durability testing is summarized, providing empirical confirmation of the optical design.

Tu5.5
38 dB Gain E-Band Bismuth-Doped Fiber Amplifier, Aleksandr I. Donodin[1], Vladislav Dvoyrin[1], Egor Manuylovich[1], Mikhail Melkumov[2], Valery Mashinsky[2], Sergei Turistyn[1]; *[1]Aston Univ., UK; [2]Naucnyj centr volokonnoj optiki imeni E M Dianova Rossijskoj 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.

Tu5.6
Impact of Pump Phase Modulation on Fibre Optical Parametric Amplifier Performance for 16-QAM Signal Amplification, Mariia Bastamova[1], Vladimir Gordienko[1], Andrew Ellis[1]; *[1]Aston Univ., UK.* We examine impact of fibre optical parametric amplifier pump phase modulation 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 0.1dB at BER of 0.03.

Tu5.7
Impact of Splice Loss on Inter-Core Crosstalk in Bidirectional Multi-Core Fibre Transmission and Its Estimation Method, Atsushi Nakamura[1], Yusuke Koshikiya[1]; *[1]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.

SC2 – Photonic Devices & Technologies – Posters

Tu5.8
Resonant-Cavity Two-Dimensional Photodetector Array and its Application to WDM-FSO Communication, Toshimasa Umezawa[1], Shoichi Takamizawa[2], Atsushi Matsumoto[1], Kouichi Akahane[1], Atsushi Kanno[1], Naokatsu Yamamoto[1], Tetsuya Kawanishi[2,1]; *[1]National Inst. of Information and Com, Japan; [2]Waseda Univ., Japan.* We present a resonant-cavity two-dimensional photodetector array device integrated with small photodetector pixels of different cavity lengths. A proof of concept in this device for WDM-FSO communication was successfully demonstrated at 25-Gbps per channel.

Tu5.9
Red-Detuned Excitation of a Quantum Emitter, Yusuf Karli[1], Florian Kappe[1], Vikas Remesh[1], Thomas K. Bracht[3], Julian Münzberg[1], Saimon Covre da Silva[2], Tim Seidelmann[4], Vollrath Martin Axt[4], Armando Rastelli[2], Doris E. Reiter[3], Gregor Weihs[1]; *[1]Universitat Innsbruck, Austria; [2]Johannes Kepler Universitat Linz, Austria; [3]Westfalische Wilhelms-Universitat Munster, Germany; [4]Universitat Bayreuth, Germany.* We report a novel, red-detuned, below band-edge excitation of a quantum emitter that promises high purity single photons without the need for polarization filtering.

Tu5.10
Low-Optical-Return Multimode Interference Photodiodes with Small Capacitance for Polarization-Diverse Optical Receivers, Hirotaka Uemura[1], Naoki Matsui[1], Reona Motoji[1], Dan Maeda[1], Tomoya Sugita[1]; *[1]Kyocera, Japan.* We designed and characterized a waveguide photodiode with a multimode interferometer. The photodiode with two light input ports showed high sensitivity, small junction capacitance, and low optical coupling between the two light input ports, which enables high-speed and polarization-diverse optical receivers with low optical returns.

Tu5.11
Variable Mode-Dependent-Loss Equalizer Based on Silica-PLC for Two-LP-Mode Transmission, Takayoshi Mori[1], Takeshi Fujisawa[2], Junji Sakamoto[3], Yoko Yamashita[1], Taiji Sakamoto[1], Ryota Imada[1], Ryoto Ima[2], Takanori Sato[2], Kei Watanabe[3], Ryoichi Kasahara[3], Toshikazu Hashimoto[3], Kunimasa Saitoh[2], Kazuhide Nakajima[1]; *[1]Access Network Service Systems Laboratories, NTT Corporation, Japan; [2]Graduate School of Information Science and Technology, Hokkaido Univ., Japan; [3]Device Technology 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.

Tu5.12
A Novel High Speed Directly Modulated Dual Wavelength 1.3 µm DFB Laser for THz Communications, Xuyuan Zhu[1], Xiaobo La[1], Jing Guo[1], Zhenyu Li[1], Lingjuan Zhao[1], Wei Wang[1], Song Liang[1]; *[1]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.

Tu5.13
All-Optical Switching Using a Photonic Crystal Molecule with Asymmetric Fano Lineshape, Quentin Saudan[1], Dagmawi A. Bekele[1], Meng Xiong[1], Kresten Yvind[1], Jesper Mørk[1], Michael Galili[1]; *[1]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.

Tu5.14
Ultra-Fast Optical Switching Using Differential Control Method, Kohei Iino[1]; Tomohiro Kita[1]; *[1]Department of Applied Physics, Waseda Daigaku Riko Gakujutsuin, 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 28 ns for τ_{rise} and 20 ns for τ_{fall}, extremely fast optical switching operation has been demonstrated.

Tu5.15
High-Efficiency Optical Phase Conjugation in a Single Ultra-low-Loss Silicon Waveguide for Nonlinearity Compensation, Shihan Hong[2], Mingming Tan[1], Andrew Ellis[1], Abdallah Ali[1], Long Zhang[2], Mingfei Ding[2], Shujun liu[2], Baobao Chen[2], Zhihuan Ding[2], Gangmin Li[2], Yiwei Xie[2], Daoxin Dai[2]; *[1]Aston Univ., UK; [2]Zhejiang Univ., China.* We demonstrate the optical phase conjugation technique using a silicon spiral 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.

Tu5.16
Experimental Demonstration of an All-Optical 2-bit Address Router Look-Up Table, Theodoros Moschos[1], Stelios Simos[1], Chris Vagionas[1], Theoni Alexoudi[1], Nikos Pleros[1]; *[1]Aristoteleio Panepistimio Thessalonikis, Greece.* We experimentally demonstrate an all-optical 2-bit Address-Look Up table combining optical CAM and RAM tables with an optical Encoding/Decoding circuit. Error-free operation at 10Gb/s has been obtained for different CAM/RAM row contents.

Tu5.17
Fully Integrated Silicon Photonic Circuit Technology With SiN Passives, Ge Photodetectors and III-v/Si SOAs, Martin Peyrou[1], Jason Mak[1], Torrey Thiessen[1], Kevin Froberger[1], Florian Denis-Le-Coarer[1], Zheng Yong[1], Laurent Milord[1], Marylise Marchenay[1], Frédéric Mazur[1], Yannis Le Guennec[2], Christophe Jany[3], Joyce K.S. Poon[4,5], Sylvie Menezo[1]; *[1]Scintil Photonics, France; [2]Grenoble Images Parole Signal Automatique, France; [3]Commissariat a l'energie atomique et aux energies alternatives Laboratoire d'electronique et de technologies de l'information, France; [4]Univ. of Toronto, Canada; [5]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.

Tu5.18
1 x 5 Silicon Nitride MEMS Optical Switch, Suraj Sharma[1], Niharika Kohli[2], Michael Ménard[1], Frédéric Nabki[1]; *[1]École de technologie supérieure, Canada; [2]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.

SC3 – Photonic Integrated Circuits, Assemblies & Packaging – Posters

Tu5.19
Enabling Optical Modulation Format Identification Using an Integrated Photonic Reservoir and a Digital Multiclass Classifier, Guillermo von Hünefeld[1,2], Gregor Ronniger[1], Pooyan Safari[1], Isaac Sackey[1], Rijil Thomas[3], Enes Seker[3,4], Piotr Cegielski[3], Stephan Suckow[3], Max Lemme[3], David Stahl[5], Sarah Masaad[6], Emmanuel Gooskens[6], Peter Bienstman[6], Colja Schubert[1], Johannes Karl Fischer[1], Ronald Freund[1,2]; *[1]Fraunhofer-Institut fur Nachrichtentechnik Heinrich-Hertz-Institut HHI, Germany; [2]Technische Universitat Berlin, Germany; [3]AMO GmbH, Germany; [4]Rheinisch-Westfalische Technische Hochschule Aachen, Germany; [5]ID Photonics GmbH, Germany; [6]Universiteit 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 OOK, PAM4, BPSK and QPSK is successfully achieved.

Tu5.20
Reception of Frequency-Coded Synapses Through Fabry-Perot SOA-REAM Integrating Weighting and Detection Functions, Margareta Vania Stephanie[2], Florian Honz[2], Nemanja Vokic[2], Winfried Boxleitner[2], Michael Waltl[1], Tibor Grasser[1], Bernhard Schrenk[2]; *[1]Inst. for Microelectronics, TU Wien, Austria; [2]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.

Tu5.21
Photonic Inverse Design of Compact Stokes-Vector Receivers on Commercial Foundry Platforms, Alec Hammond[1], Alex Kaylor[1], Joel Slaby[1], Michael Probst[1], Stephen Ralph[1]; *[1]Georgia Inst. of Technology, USA.* We present and experimentally validate an ultra-compact, silicon-photonics, Stokes-vector receiver designed entirely using topology optimization. The system occupies just 0.06 mm^2 and is amenable to optical/electrical flip-chip packaging. Experiments demonstrate a median error angle of 14 degrees without tuning across the Poincaré sphere and optical C-band.

Tu5.22
L-Band Mode and Wavelength Conversion in a Periodically Poled Lithium Niobate Ridge Waveguide, Sijing Liang[1], Yongmin Jung[1], Kyle Bottrill[1], Peng Zhang[2], David Richardson[1], Lin Xu[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK; [2]HiSilicon Optoelectronics Co., Ltd., China.* We present simultaneous mode and wavelength conversion over wavelengths from 1570 nm to 1610 nm based on intermodal 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.

Tu5.23
136-Gbit/s Optical QAM-OFDM Receiver With MZI DeMux Waveguide Ge Photodiode for O-Band SMF Link, Yu-You Chen[1], Kuo-Fang Chung[1], Jyun-Yang Su[1], Chih-Hsien Cheng[2], Tien-Tsorng Shih[3], Ding-Wei Huang[1], Gong-Ru Lin[1,4]; *[1]Graduate Inst. of Photonics and Optoelectronics, and Department of Electrical Engineering, National Taiwan Univ., Taiwan; [2]Research Center for Advanced Science and Technology, Univ. of Tokyo, Japan; [3]Department of Electronic Engineering, National Kaohsiung Univ. of Science and Technology, Taiwan; [4]Tektronix-NTU Joint Research Center, National Taiwan Univ., Taiwan.* By using a Ge lateral p++/p+/n+/n++ junction waveguide photodiode integrated with a dualstage Mach-Zehnder interferometric waveguide demultiplexer for 4-channel CWDM SMF network at Oband, 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 Qiu[1], Yong Liu[1], Xiansong Meng[1], Xiaowei Guan[1,2], Yunhong Ding[1], Hao Hu[1]; *[1]Technical Univ. of Denmark, Denmark; [2]Jiaxing 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/π.

SC4 – Techniques for Digitally Enhancing Optical Communication – Posters

Tu5.25
Adaptive Multi-Layer Filters for Compensating for Impairments in Transmitters and Receivers for SDM Transmission, Manabu Arikawa[1,2], Kazunori Hayashi[2]; *[1]NEC Corporation, Japan; [2]Kyoto Univ., Japan.* An extended adaptive multi-layer filter architecture that compensates for transmitter/receiver impairments in SDM transmission is presented. Simultaneous compensation and monitoring of receiver IQ skew was experimentally demonstrated for -10 to +10 ps in WDM/SDM transmission of 32-Gbaud PDM-64QAM signals over 102-km coupled 4-core fiber.

Tu5.26
Experimental Study of the Equalization Requirements of a 2.5D Co-Packaged 16-nm CMOS Optical Receiver up to 160 Gb/s, Dhruv Patel[1], Bahaa Radi[1], Alireza Sharif-Bakhtiar[2,3], Anthony Chan Carusone[1,3]; *[1]Univ. of Toronto, Canada; [2]Huawei Technologies, Canada; [3]Alphawave IP, Canada.* We demonstrate the DSP-based feed-forward and decision-feedback equalization requirements in 2.5D co-packaged CMOS optical receivers. Experimental results confirm optical reception up to 160-Gb/s/λ PAM-4 and 90-Gb/s/λ NRZ signaling with a bandwidth-limited prototype comprised of a TIA in 16-nm FinFET CMOS co-packaged with a commercial photodiode.

Tu5.27
Investigating the Performance and Suitability of Neural Network Architectures for Nonlinearity Mitigation of Optical Signals, Vegenshanti Dsilva[2], Isaac Sackey[2], Gregor Ronniger[2], Guillermo von Hünefeld[2,1], Binoy Chacko[2], Ronald Freund[2,1], Colja Schubert[2]; *[1]Technische Universitat Berlin, Germany; [2]Fraunhofer-Institut fur 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 SSMF and 10-km DCF. 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 Wang[1], Kaihui Wang[1], Yuxuan Tan[1], Junjie Ding[1], Bohan Sang[1], Feng Wang[1], Bowen Zhu[1], Miao Kong[1], Wen Zhou[1], Jianjun Yu[1]; *[1]Fudan 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, Zhuo Chen[1], Xiaoxiao Dai[1], Junyuan Nie[1], Shenmao Zhang[1], Jiahao Zhou[3], Jing Zhang[3], Ying Qiu[2], Ming Luo[2], Qi Yang[1], Lei Deng[1], Mengfan Cheng[1], Kun Qiu[3], Deming Liu[1]; *[1]School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China; [2]State Key Laboratory of Optical Communication Technologies and Networks, China Information Communication Technologies Group Corporation (CICT), China; [3]Key Lab. of Optical Fiber Sensing and Communications, Univ. of Electronic Science and Technology of China, China.* We propose a complexity-reduced LUT-MLSE for DSB C-band IM/DD transmission based on pre-decision-assisted trellis compression and path-decision-assisted Viterbi algorithm with a 99.65% complexity reduction. We successfully demonstrate a 20-km 100-Gb/s PAM-6 and a 30-km 80-Gb/s PAM-4 C-band transmission over dispersion-uncompensated links.

Tu5.30
Asymmetric Self-Coherent Detection with Mitigated SSBI Enhancement Using Partial pre-Compensation, Xueyang Li[1], Honglin Ji[1], Lulu Liu[1], Shangcheng Wang[1], Zhixue He[1], Weisheng Hu[1]; *[1]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.

SC5 – Theory of Optical Communications – Posters

Tu5.31
Noise Analysis for the Communication System Using High-Speed DAC and ADC, Tong Ye[1], Xiaofei Su[1], Chengwu Yang[1], Jingnan Li[1], Zhenning Tao[1], Hisao Nakashima[2], Takeshi Hoshida[2]; *[1]Fujitsu R&D Center, China; [2]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, Emanuele E. Virgillito[1], Andrea Castoldi[2], Andrea D'Amico[1], Stefano Straullu[3], Rudi Bratovich[2], Fransisco Martinez Rodriguez[2], Andrea Bovio[2], Rosanna Pastorelli[2], Vittorio Curri[1]; *[1]Politecnico di Torino, Italy; [2]SM-Optics, Italy; [3]Links Foundation, Italy.* We simulate and observe the buildup of coherency 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.

Tu5.33
Robust Rate-Adaptive Probabilistic Balanced SOP Transmission for Upgradeable Dispersion Managed Links, Patrick Schulte[1], Stefano Calabrò[1], Georg Böcherer[1], Maxim Kuschnerov[1]; *[1]Huawei Technologies Duesseldorf GmbH, Germany.* 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.

Tu5.34
Low-Latency Low-Overhead Zipper Codes, Bashirreza Karimi[1], Masoud Barakatain[1], Yoones Hashemi[1], Deyuan Chang[1], Hamid Ebrahimzad[1], Chuandong Li[1]; *[1]Huawei Technologies Co. Ltd, Canada.* A new hard-decision FEC scheme, suitable for high-throughput applications, is proposed that is based on zipper framework and is able to reduce the required memory and latency significantly compared to the conventional zipper codes.

Tu5.35
Irregular QAM Formats for Short-Reach Amplifier-Less Coherent Optical Systems, Mengfan Fu[1], Qiaoya Liu[1], Yunyun Fan[1], Lilin Yi[1], Weisheng Hu[1], Qunbi Zhuge[1]; *[1]Shanghai Jiao Tong Univ., China.* A low-complexity scheme is proposed to realize irregular QAM formats in amplifier-less coherent optical systems. The simulation results show 36QAM and 49QAM achieve 2.32 dB and 1.9 dB gains of power budget over 64QAM at net bit rates of 650 Gbit/s and 750 Gbit/s, respectively.

SC6 – Optical Transmission Systems – Posters

Tu5.36
Demonstration of Real-Time Unrepeatered MDM Transmission Over 200-km FMF With Commercial 400G System and ROPA, Dawei Ge[1], Dong Wang[1], Dechao Zhang[1], Yunbo Li[1], Sheng Liu[1], Shan Cao[1], Lei Shen[2], Lei Zhang[2], Changkun Yan[2], Liuyan Han[1], Han Li[1]; *[1]China Mobile Research Inst., China; [2]Yangtze Optical Fibre and Cable Joint Stock Ltd Co, China.* By using LP01 and LP02 in a weakly-coupled double-ring-core FMF, a record real-time unrepeatered MDM transmission over 200-km FMF (54.5dB loss for LP01 and 67.5dB loss for LP02) with 400 Gbps DP-16QAM-PCS commercial system and remote optically pumped amplifiers for the first time.

Tu5.37
800-Gbit/s/Carrier TPS-64QAM WDM Coherent Transmission Over 2,400 km Utilizing Low-Complexity Separated Pruning DNN-Based Nonlinear Equalization, Bohan Sang[1], Miao Kong[1], Yuxuan Tan[1], Kaihui Wang[1], Li Zhao[1], Wen Zhou[1], Ze Dong[2], Bo Liu[3], Xiangjun Xin[2], Weizhang Chen[4], Bing Ye[4], Jianjun Yu[1]; *[1]Fudan Univ., China; [2]Beijing Inst. of Technology, China; [3]Nanjing Univ. of Information Science and Technology, China; [4]ZTE Corp, China.* We experimentally demonstrated 800-Gbit/s/carrier WDM coherent transmission over 2,400-km based on 100-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.

Tu5.38
Monitoring of Generalized Optical Signal-to-Noise Ratio Using in-Band Spectral Correlation Method, Choloong Hahn[1], Junho Chang[1], Zhiping Jiang[1]; *[1]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.

Tu5.39
Swiss Fiber Network for Dissemination of Optical Frequencies in the L-Band of a Telecommunication Network, Dominik Husmann[1], Jérôme Faist[2], Fabian Mauchle[3], Frédéric Merkt[2], Stefan Willitsch[4], Jacques Morel[1]; *[1]Swiss Federal Inst. of Metrology METAS, Switzerland; [2]Eidgenossische Technische Hochschule Zurich, Switzerland; [3]SWITCH, Switzerland; [4]Universitat Basel, Switzerland.* 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 data network. Our solution provides efficient shared use of existing fibers for ultra-precise time and frequency signals for scientific applications and beyond.

Tu5.40
Single-Shot Frequency-Resolved Imbalance Characterization for Coherent Transceivers Based on Inter-Channel Response Ratio, Honglin Ji[1,2], Jingchi Li[3], Xingfeng Li[3], Zhen Wang[3], Ranjith Rajasekharan Unnithan[2], Yikai Su[3], Weisheng Hu[1,3], William Shieh[2]; *[1]Peng Cheng Laboratory, Australia; [2]The Univ. of Melbourne, Australia; [3]Shanghai Jiao Tong Univ., China.* 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-Gbaud PCS-256QAM signal with a 1.05-Tb/s raw data rate.

SC7 – Core & Metro Networks – Posters

Tu5.41
Generalizable QoT Estimation Based on Spectral Data Driven LSTM in Exact Component Parameter Agnostic Networks, Lars E. Kruse[1], Sebastian Kühl[1], Stephan Pachnicke[1]; *[1]Christian-Albrechts-Universitat zu Kiel, Germany.* We investigate the robustness of our spectral data driven machine learning based QoT estimator by artificially noising the input features. The estimator shows superior robustness against feature changes compared to a non-spectral estimator. We validate its generalization ability and robustness on an unseen experimental dataset.

Tu5.42
Dual Time and Frequency Domain Optical Layer Digital Twin, Mariano Devigili[1], Marc Ruiz[1], Nelson Costa[2], Antonio Napoli[3], João Pedro[2], Luis Velasco[1]; *[1]UPC, Spain; [2]Infinera Unipessoal Lda., Portugal; [3]Infinera, Germany.* We demonstrate a digital twin for failure detection in optical networks. Artificial neural networks-based models for optical constellation analysis enable predicting the transmitted signal in the time domain whereas analytical models are usually used to estimate their spectral evolution.

Tu5.43
Impact of Connection Flexibility in Spatial Cross-Connect on Core Resource Utilization Efficiency and Node Cost in Spatial Channel Networks, Kako Matsumoto[1], Koki Miura[1], Yudai Uchida[1], Masahiko Jinno[1]; *[1]Kagawa Univ., Japan.* Spatial bypassing and spectral grooming in a spatial channel network (SCN) achieve high resource utilization and cost-effectiveness. We show how spatial cross-connect architectures and the associated degree of connection constraints affect the required number of cores and the total node cost of an SCN.

Tu5.44
Multi-Agent -Based Dynamic Optical Subcarrier Allocation for Near Real-Time P2MP Operation, Hailey Shakespear-Miles[1], Marc Ruiz[1], Antonio Napoli[2], Luis Velasco[1]; *[1]Universitat Politecnica de Catalunya, Spain; [2]Infinera Germany, Germany.* We propose a multi-agent system (MAS) to manage subcarrier allocation in point-to-multipoint connectivity based on Digital Subcarrier Multiplexing. Similar performance to a centralized approach is shown, which allows for near-real time operation with increased scalability.

Tu5.45
Comparative Analysis of Received Optical Powers in PON Through Measurements by Power Meters and Telemetry, Philippe Chanclou[1], Stephane Le Huerou[1], Malo Follain[1], Julien Landos[1], Frederic Miet[1], Alain Marie[1], Fabienne Saliou[1], Gaël Simon[1]; *[1]Orange Innovation, France.* In the context of improving G-PON and XGS-PON diagnostic, we compare and analyse the quality of received optical power measured by PON power meters and network equipment at both ends.

Tu5.46
A Sparse-Readout Reservoir-Computing Based Equalizer for 100 Gb/s/λ PON, Xiaoan Huang[1], Dongxu Zhang[1], Xiaofeng Hu[1], Kaibin Zhang[1]; *[1]Nokia Bell Labs Shanghai, China.* A low-power sparse-readout reservoir-computing based equalizer is proposed and evaluated by experiments on a 100-Gbps/λ PON testbed. Results demonstrate that it is feasible to greatly reduce the readout layer's complexity while achieving a 29-dB power budget. Integrated photonics implementation issues are also discussed.

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

Tu5.47
Demonstration of Low Latency 25G TDM-PON With Flexible Multizone-Based ONU Activation for Time Critical Services, Kwang Ok Kim[1], Kyeong Hwan Doo[1], Hwan Seok Chung[1]; *[1]Electronics and Telecommunications Research Inst., Korea (the Republic of).* We successfully demonstrate the flexible multizone-based ONU activation to reduce effectively a quiet window in TDM-PON. The total time for 64 ONUs registration is reduced to 74.3 %.

Tu5.48
Data-Centric Transmission with Adaptive FEC for Ultra-Low Latency Resource Sharing in Wide Area, Toshiya Matsuda[1], Kota Nishiyama[1], Takeshi Seki[1], Takashi Miyamura[1]; *[1]Nihon Denshin Denwa Kabushiki Kaisha, Japan.* 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-GT/s optical interfaces up to 90 km with less than 1.5% increase in latency due to network equipment.

Tu5.49
Cost-Effective Edge-Side Single LD-Drive Protection with Reflection Blocking for Single Star/Passive Double Star Link Switchable Point-to-Multipoint Full-Duplex Fiber Transmission, Shota Eguchi[1], Tomoya Nakagawa[1], Takahiro Kodama[1]; *[1]Kagawa Univ., Japan.* We propose full-single λ operation under normal conditions and an ONU-side Fresnel antireflection for bypass and backup path switchable point-to-multipoint systems. The 4ONU optical coherent system provides full-duplex fiber transmission without power penalty using wavelength conversion and shared link switching for primary link failure.

Tu5.50
Field Trial of Remotely Controlled Smart Factory Based on PON Slicing and Disaggregated OLT, Yong-Wook Ra[1], ChanSung Park[1], KyoungHoi Hwang[2], Kyeong Hwan Doo[1], Kwang Ok Kim[1], Hanhyub Lee[1], Taesik Chung[1], JaeSheung Shin[1], Hwan Seok Chung[1]; *[1]Electronics and Telecommunications Research Inst., Korea (the Republic of); [2]HFR 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.

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

Tu5.51
Design of RoF-Based Fiber-Wireless System for THz-Band 6G Indoor Network, Minkyu Sung[1], Sooyeon Kim[1], Eon-Sang Kim[1], Sang-Rok Moon[1], Mugeon Kim[1], IL-Min Lee[1], Kyung Hyun Park[1], Joon Ki Lee[1], Seung-Hyun Cho[1]; *[1]Electronics and Telecommunications Research Inst., Korea (the Republic of).* We experimentally demonstrate RoF-based fiber-wireless seamless system for THz-band 6G indoor network. Based on the theoretical analyses and experimental results, we present design issues in RoF-based fiber-wireless system.

Tu5.52
3-Dimensional Visible Light Positioning (VLP) Using Two-Stage Neural Network (TSNN) and Signal-Strength-Enhancement (SSE) to Mitigate Light Non-Overlapping Regions, Li-Sheng Hsu[1], Chi-Wai Chow[1], Yang Liu[2], Yun-Han Chang[1], Deng-Cheng Tsai[1], Tun-Yao Hung[1], Yuan-Zeng Lin[1], Yin-He Jian[1], Chien-Hung Yeh[3]; *[1]National Yang Ming Chiao Tung Univ., Taiwan; [2]Philips, Hong Kong; [3]Feng Chia Univ., Taiwan.* We propose and present the first demonstration of a 3-D visible-light-positioning (VLP) utilizing Two-Stage-Neural-Network (TSNN) and Signal-Strength-Enhancement (SSE) to mitigate the light-non-overlapping-regions. In a practical room of 200×150×300 cm^3, the average errors are <9 cm.

Tu5.53
Experimental Demonstration of a Novel OFDM-NOMA Bit and Power Loading Algorithm for Hybrid Unicast and Broadcast Transmission in Cooperative VLC Systems, Chengju Hu[1], Geyang Wang[1], Shuhua Song[1], Jian Zhao[1]; *[1]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 1.1~1.9-Gbit/s cooperative VLC experiments that the proposed algorithm outperforms conventional OFDM-NOMA, DFT-S OFDM-NOMA, and OCT-P OFDM-NOMA regardless of the unicast/broadcast data rates and channel conditions.

Tu5.54
Programmable Anti-Logarithm Linearization Circuits (PALC) for Self-Adaptive Signal-to-Noise Ratio Optimization in Photovoltaic Visible Light Communications, Shuyan Chen[1], Liqiong Liu[1], Lian-Kuan Chen[1]; *[1]The Chinese Univ. of Hong Kong, Hong Kong.* A programmable anti-logarithm linearization circuit (PALC) for linearizing photovoltaic modules is proposed and implemented. With the investigation of an optimal number of diodes required in PALC under different scenarios, a BER reduction from 1.4×10^{-1} to 8.2×10^{-3} 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, Liuyan Chen[1], Chin Wan Oh[1], Jeffrey Lee[1], Xuebing Zhang[2], Ton Koonen[1]; *[1]Electrical Engineering, Technische Universiteit Eindhoven, Netherlands; [2]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 1.1× 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, Chuanming Huang[1], Hugui Jin[1], Mengfan Cheng[1], Qi Yang[1], Deming Liu[1], Ming Tang[1], Lei Deng[1]; *[1]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 Gb/s 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 Cipher Generation via Analog IFoF Transmission With a DML, Ken Tanizawa[1], Fumio Futami[1]; *[1]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 cipher 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.

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

Tu5.58
Multilevel Clustering in Point-to-Point Fiber Network Design, Simon Van den Eynde[1], Pieter Audenaert[1], Didier Colle[1], Mario Pickavet[1]; *[1]IDLab, Ghent Univ. - imec, Belgium.* We propose and test three metaheuristic approaches to extend a single-level FTTH network design heuristic to multiple levels. Each heuristic is evaluated on realistic graphs with over 30000 nodes and 800 terminals. We found a small but significant cost improvement.

Tu5.59
DeepDefrag: Spatio-Temporal Defragmentation of Time-Varying Virtual Networks in Computing Power Network Based on Model-Assisted Reinforcement Learning, Huangxu Ma[1], Jiawei Zhang[1], Zhiqun Gu[1], Hao Yu[2], Tarik Taleb[2], Yuefeng Ji[1]; *[1]Beijing Univ. of Posts and Telecommunications, China; [2]Center for Wireless Communications, Oulun Yliopisto Tieto- ja sahkotekniikan tiedekunta, 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 Arpanaei[1], Behnam Shariati[2], Pooyan Safari[2], Mehdi Ranjbar[4], José Alberto Hernández[1], Andrea Carena[3], Johannes Karl Fischer[2], David Larrabeiti[1]; *[1]Univ. Carlos III of Madrid, Spain; [2]Fraunhofer Inst. for Telecommunications, Germany; [3]Politecnico di Torino, Italy; [4]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[1], Xiaodong Gui[1], Xin Lei[1], Chongjin Xie[2], Ying Zhang[3], Xiaosheng You[3]; *[1]Alibaba Group, China; [2]Alibaba Group, USA; [3]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 • Joint Poster Session I—Continued

Tu5.62
Time-Aware Deterministic Bandwidth Allocation Scheme for Industrial TDM-PON, Chen Su[1], Jiawei Zhang[1], Hao Yu[2], Tarik Taleb[2], Yuefeng Ji[1]; *[1]Beijing Univ. of Posts and Telecommunications, China; [2]Oulun Yliopisto Tieto- ja sahkotekniikan 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 Assisted by Reinforcement Learning in Multi-Band Optical Networks, Abdennour Ben Terki[3], João Pedro[1], Antonio Eira[1], Antonio Napoli[2], Nicola Sambo[3]; *[1]Infinera Corp, Portugal; [2]Infinera Corp, Germany; [3]TeCIP, Scuola 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 Centofanti[1], Andrea Marotta[1], Dajana Cassioli[1], Fabio Graziosi[1], Nicola Sambo[2], Luca Valcarenghi[2], Chris Bernard[3], Hal Roberts[3]; *[1]Department of Information Engineering, Computer Science and Mathematics (DISIM), Univ. Of L'Aquila, Italy; [2]Scuola Superiore Sant'Anna, Italy; [3]Calix, Inc, USA.* 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, Yuansen Cheng[1], Shifeng Ding[1], Chun-Kit Chan[1]; *[1]The Chinese Univ. of Hong Kong, Hong Kong.* We propose a pointer network-based 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 Mesquita[1], Karcius D. Assis[1,2], Raul Almeida[3], Reza Nejabati[2], Dimitra Simeonidou[2]; *[1]Federal Univ. of Bahia, Brazil; [2]Univ. of Bristol, UK; [3]Universidade Federal de Pernambuco, Brazil.* This paper presents a channel formulation optimisation approach to design 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.

CLEO®/Europe Focus Meeting – Posters

Tu5.67
DV-QKD Coexistence With 1.6 Terabit/s Classical Channels in Free Space Using Fiber-Wireless-Fiber Terminals, Obada Alia[1], Andy Schreier[2], Rui Wang[1], Sima Bahrani[1], Ravinder Singh[2], Grahame Faulkner[2], John Rarity[3], Dominic O'Brien[2], George Kanellos[1], Reza Nejabati[1], Dimitra Simeonidou[1]; *[1]School of Computer Science, Electrical & Electronic Engineering and Engineering Maths (SCEEM), High Performance Network Group, UK; [2]Univ. of Oxford Department of Engineering Science, UK; [3]H. 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 Gpbs 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^{3+} Doped Crystals with Fluorite Structure as Qubits, Yurii V. Orlovskii[1], Ekaterina Vagapova[1], Viktor Peet[1], Elena Vinogradova[1], Leonid Dolgov[1], Vadim Boltrushko[1], Vladimir Hizhnyakov[1]; *[1]Inst. of Physics, Tartu Ulikool Loodus- ja tehnoloogiateaduskond, Estonia.* One- and two-exciton collective states with quantum entanglement in ion pairs in Nd^{3+}: CaF_2 and Nd^{3+}: SrF_2 crystals are studied. It is shown that the strong resonance electrical exchange interaction with spin-flip determines the structure of the luminescence excitation spectra of the one-exciton state.

Tu5.69
Direct Comparison of on-Chip Hong-Ou-Mandel Interference of Photon Pairs From Ring Resonators and Straight Waveguides., Jong-Moo Lee[1]; *[1]Electronics and Telecommunications Research Inst., Korea (the Republic of).* 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-photonic circuit. The ring is tuned to the pump wavelength or not by choice, to turn on and off the influence of the ring, respectively.

Tu5.70
Space-Wavelength-Division-Multiplexing-Based Synergistic Transmission in Quantum Key Distribution Coexisting with Classical Communications, Weiwen Kong[1], Yongmei Sun[1], Xueqin Ren[1], Yaoxian Gao[1], Yuefeng Ji[1]; *[1]Beijing Univ. of Posts and Telecommunications, China.* We propose a synergistic core and wavelength allocation (SCWA) scheme to simultaneously improve the performance of classical optical communication and quantum key distribution. The experimental results show that SCWA scheme can improve the synergistic degree up to 0.57 compared to quantum unequal frequency spacing scheme.

Tu5.71
Computing With an All-Optical Cache Hierarchy Using Optical Phase Change Memory as Last Level Cache, Haiyang Han[1], Theoni Alexoudi[2], Chris Vagionas[2], Nikos Pleros[2], Nikos Hardavellas[3,1]; *[1]Department of Electrical and Computer Engineering, Northwestern Univ., USA; [2]Department of Informatics, Aristoteleio Panepistemio Thessalonikes, Greece; [3]Department 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 Maeder[1], Fabian Kaufmann[1], Giovanni Finco[1], David Pohl[1], Jost Kellner[1], Xiyue S. Wang[1], Rachel Grange[1]; *[1]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, Menelaos Skontranis[1], George Sarantoglou[1], Adonis Bogris[2], Charis Mesaritakis[1]; *[1]Univ. of Aegean, Greece; [2]Panepistemio Dytikes Attikes Schole Mechanikon, Greece.* We present numerical results from a spectro-temporal reservoir computing based on a Fabry-Perot laser. By exploiting longitudinal modes, we achieved tunable real time processing rate, reaching up to 2.38 GHz for an image classification task with elevated accuracy.

17:30–19:00
We5 • Joint Poster Session II

SC1 – Novel Fibres, Fibre Devices & Amplifiers – Posters

We5.1
Data-Driven Optimization of Giles Parameters of Super L-Band Erbium Doped Fibers, Maish Sharma[1], Frederic Maes[1], Lixian Wang[1], Youès Messaddeq[2], Sophie Larochelle[2], Zhiping Jiang[1]; *[1]Huawei Technologies Canada, Canada; [2]Universite Laval, Canada.* Precise modeling of super L-band erbium doped fibers (EDFs) is more challenging than conventional C-band EDFs. We demonstrated a data-driven Giles parameter optimization routine that leads to significant precision improvement of the simulated gain and noise figure.

We5.2
Gain Behavior of E+S Band Hybrid Bismuth/Erbium-Doped Fiber Amplifier Under Different Conditions, Frederic Maes[1], Maish Sharma[1], Lixian Wang[1], Zhiping Jiang[1]; *[1]Huawei Technologies Canada, Canada.* A hybrid amplifier employing bismuth-doped and erbium-doped fibers is demonstrated which provides over 27 dB gain from 1431 nm to 1521 nm. Furthermore, we demonstrate that gain inhomogeneity occurring in bismuth-doped fibers is significantly more pronounced than in erbium-doped fibers.

We5.3
Variable Optical Attenuation Function of Core Selective Switch and Its Impact on Inter-Core Crosstalk Characteristics, Yudai Uchida[1], Tsubasa Ishikawa[1], Shoma Murao[1], Itsuki Urashima[1], Rika Tahara[1], Kyosuke Nakada[1], Masahiko Jinno[1]; *[1]Kagawa Univ., Japan.* A core selective switch (CSS) is the building block for modular spatial cross-connects in future spatial channel networks. We demonstrate the variable optical attenuation functionality in a CSS and show that inter-core crosstalk less than −37 dB can be ensured even with a 15-dB attenuation.

We5.4
All-Optical any-to-any Wavelength Conversion Across 36nm Range, Aneesh Sobhanan[1], Vladimir Gordienko[1], Chandra B. Gaur[1,2], Andrew Ellis[1]; *[1]AIPT, Aston Univ., UK; [2]SubCom LLC, USA.* We experimentally demonstrate all-optical wavelength conversion with efficiency above -5 dB from any wavelength to any other wavelength across a whole of the C band by employing two narrow-linewidth pumps in Al-doped HNLF.

We5.5
Free-Space Coupling of Few-Mode Fibre to Multi-Mode Fibre Using Digital Holography, Menno van den Hout[1], Sjoerd van der Heide[1], Thomas Bradley[1], Amado M. Velazquez-Benitez[1,2], Nicolas K. Fontaine[3], Roland Ryf[3], Haoshuo Chen[3], Mikael Mazur[3], Jose Enrique Antonio-Lopez[4], Juan Carlos Alvarado-Zacarias[4], Rodrigo Amezcua-Correa[4], Marianne Bigot[5], Adrian Amezcua-Correa[5], Pierre Sillard[5], Chigo Okonkwo[1]; *[1]Electrical Engineering, Technische Universiteit Eindhoven, Netherlands; [2]Universidad Nacional Autonoma de Mexico, Mexico; [3]Nokia Bell Labs, USA; [4]Univ. of Central Florida College of Optics and Photonics, USA; [5]Prysmian Group, France.* Off-axis digital holography is used to align a few-mode fiber to a multi-mode fiber in a free-space optical setup. Alignment based on power coupling measurements alone cannot guarantee low mode-dependent loss. The proposed alignment method enables reliable fiber coupling with low mode-dependent loss and crosstalk.

We5.6
Fiber Bragg Grating in an Antiresonant Hollow-Core Fiber, Charu Goel[1], Seongwoo Yoo[1]; *[1]Nanyang Technological Univ., Singapore.* We investigate the feasibility of a Fiber Bragg Grating (FBG) in an antiresonant hollow-core fiber by exploiting the enhanced mode-field overlap of the fundamental mode with silica cladding, in the resonant band of wavelengths. The proposed FBG can achieve high reflectivity with an insertion loss of 0.5 dB.

SC2 – Photonic Devices & Technologies – Posters

We5.7
Iron Doping for Transfer Printed High Speed EAM, Shengtai Shi[1,2], Jack Mulcahy[1,2], Xing Dai[1,2], Frank Peters[2,1]; *[1]Tyndall National Inst., Ireland; [2]Univ. College Cork, Ireland.* An iron doped InP layer is adopted to achieve a micro transfer printing (MTP) compatible high-speed electro-absorption modulator (EAM). An equivalent circuit model analysis of the transfer printed EAM is presented with a simulated speed up to 45.6 GHz. Fabrication details are also discussed.

We5.8
Compact and High-Performance Mode Evolution Based Polarization Splitter-Rotator in Standard Active Silicon Platform, Zakariya Mohammed[1], Reza Safian[2], Bruna Paredes[3], Leimeng Zhuang[2], Mahmoud Rasras[3]; *[1]Electrical and Computer Engineering, New York Univ., USA; [2]Interuniversitair Micro-Elektronica Centrum, USA; [3]Electrical and Computer Engineering, New York Univ., United Arab Emirates.* An entirely-mode-evolution-based polarization splitter-rotator assisted by a tapered TE-pass polarizer on a compact footprint of 185 μm is demonstrated. The measurement results show an insertion loss < 1.2 dB and extinction ratio > 25 dB over the complete C+L wavelength band.

We5.9
High-Speed Polarization-Insensitive Electro-Absorption Modulator Module With Low-Driving Voltage, Guangcan Chen[1], Yuanbing Cheng[1], Yanmin Yu[2], Minghui Zhang[2], Jinlin Zeng[2], Caini Zhang[2], Xin Zhang[1], Yanbo Li[1]; *[1]Huawei Technologies Co., Ltd., China; [2]Huawei Machine Co., Ltd., China.* We present a polarization-insensitive electro-absorption modulator module operating at a low driving voltage of ~1.5Vpp from 1540nm to 1560nm. The module shows a clear 50Gb/s PAM-4 eye pattern with <1.6dB TDECQ for a dynamic outer extinction ratio of more than 8 dB.

We5.10
Continuously Tuneable MZI-Based Delay Line Overcoming Delay-Bandwidth Product, Matteo Petrini[1], Seyedmohammad Seyedinnavadeh[1], Francesco Morichetti[1], Andrea Melloni[1]; *[1]Politecnico di Milano, Italy.* A silicon photonic integrated circuit, implementing a novel delay-line architecture, is proposed. The device, based on a set of four nested Mach-Zehnder Interferometers, overcomes typical delay-bandwidth product. Showing a minimum bandwidth of 20 GHz, group delay can be continuously tuned between 0 and 100 ps.

We5.11
Long-Wavelength Avalanche Photodiodes Operating Over a 30 dB Optical Input Power Range, Alberto Ciarrocchi[1], Wei Quan[1], Maria Hämmerli[1], Hektor T. Meier[1]; *[1]Albis Optoelectronics AG, Switzerland.* High-speed, long-wavelength, telecom and datacom 10 Gb/s and 25 Gb/s avalanche photodiodes (APDs) are sensitive to excessive optical input power. We explain this failure mechanism and demonstrate an optimized device structure reaching over +6 dBm optical damage threshold and verify it by testing in volume production.

We5.12
Silicon Photonics Wavelength-Independent C-Band Tunable Optical Filter With Feasible Thermal Tuning Requirements, Saif Alnairat[1,2], Benjamin Wohlfeil[1], Stevan Djordjevic[1], Bernhard Schmauss[2]; *[1]Advanced Technology, ADVA Optical Networking SE, Germany; [2]Inst. of Microwaves and Photonics (LHFT), Friedrich-Alexander-Universitat Erlangen-Nurnberg, Germany.* A filter design based on Vernier microrings and wideband directional couplers is proposed for ASE noise suppression in next generation DCI applications. We demonstrate a ~40 nm FSR-free filter with > 20.5 dB average ER and 3dB-BW of ~75 GHz, achieving wavelength independent performance and full tunability with a maximum tuning temperature of ~75 K.

We5.13
High Performance Polarization Rotator-Splitter Based on Si_3N_4 Waveguide With Relaxed Fabrication Tolerance, Xiangyang Dai[1], Heng Li[1], Su Tan[1], Yongqian Tang[1], Qiaoyin Lu[1], John F. Donegan[2], Weihua Guo[1]; *[1]Huazhong Univ. of Science and Technology, China; [2]School of Physics and CRANN and CONNECT, The Univ. of Dublin Trinity College, Ireland.* A novel polarization rotator-splitter is presented based on Si_3N_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 ~20dB with the fabrication-tolerance ~±150nm and polarization conversion-loss ~1.5dB across the C-band.

We5.14
Pre-Fabrication Performance Verification of a Topologically Optimized Mode Demultiplexer Using Deep Neural Networks, Dusan Gostimirovic[1], Md Mahadi Masnad[1], Dan-Xia Xu[2], Yuri Grinberg[3], Odile Liboiron-Ladouceur[1]; *[1]Department of Electrical and Computer Engineering, McGill Univ., Canada; [2]Advanced Electronics and Photonics Research Centre, National Research Council Canada, Canada; [3]Digital Technologies Research Centre, National Research Council Canada, Canada.* Photonics 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.

We5.15
Electro-Optical Frequency Comb Generator Based on Electrical and Optical Dual Resonance Enhanced Structure, Huilan Tu[2], Jia Liu[2], Haizhong Weng[1], Qiaoyin Lu[2], Lirong Huang[2], John F. Donegan[1], Weihua Guo[2]; *[1]CRANN and AMBER, Trinity College Dublin, Ireland; [2]Huazhong 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
Photonic Integrated Spatial Mode Controller Based on Thin Film Lithium Niobate, Yunfan Wu[1], Yudan Zhang[1], Su Tan[1], Xiangyang Dai[1], Qiaoyin Lu[1], John F. Donegan[2], Weihua Guo[1]; *[1]Huazhong Univ. of Science and Technology, China; [2]The Univ. of Dublin Trinity College, Ireland.* We demonstrate the 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 Yeo[1], Alvin Leow[2], Peng Kian Tan[1], Lijiong Shen[1], Christian Kurtsiefer[1,2]; *[1]Center for Quantum Technologies, Singapore; [2]Department of Physics, 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.

SC3 – Photonic Integrated Circuits, Assemblies & Packaging – Posters

We5.18
Study of Efficient Photonic Chromatic Dispersion Equalization Using MZI-Based Coherent Optical Matrix Multiplication, Sizhe Xing[1], Guoqiang Li[1], Ziwei Li[1], Nan Chi[1], Junwen Zhang[1]; *[1]Fudan 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[1], Xiangfeng Chen[2,3], Didier Colle[1], Wim Bogaerts[2,3], Mario Pickavet[1]; *[1]Department of Information Technology, IDLab, Ghent Univ. - IMEC, Belgium; [2]Ghent Univ. - IMEC, Photonic Research Group, Department of Information Technology, Gent, Belgium, Belgium; [3]Center 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 Giamougiannis[1], Apostolos Tsakyridis[1], Miltiadis Moralis-Pegios[1], Christos Pappas[1], Manos Kirtas[1], Nikolaos Passalis[1], David Lazovsky[2], Anastasios Tefas[1], Nikos Pleros[1]; *[1]Aristoteleio Panepistemio Thessalonikes, Greece; [2]Celestial 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 dataset 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[1,4], Jae Hyun Jin[1], Chul Wook Lee[2], Ki Soo Kim[2], Oh Kee Kwon[2], Kyoung Su Park[3], Jong-In Shim[4]; *[1]Essence Photonics Inc., Korea (the Republic of); [2]Photonics Convergence Components Research Group, Electronics and Telecommunications Research Inst., Korea (the Republic of); [3]Department of electronics engineering, Kangwon National Univ., Korea (the Republic of); [4]Department of Photonics and Nanoelectronics, 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 fabricate device shows 16 channel operation with clear eye patterns.

We5.22
Simulation of an Arbitrary Optical Switch on a Dense Programmable Photonic Processor, Aitor López[1], Erica Sánchez[1], Daniel Perez[1,2]; *[1]Universitat Politècnica de València, Spain; [2]iPronics 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

We5.23
Widely Nonlinear Phase Retrieval for Direct Detection-Based Digital Twinning of Coherent Optical Components, Yuki Yoshida[1], Setsuo Yoshida[2], Shoichiro Oda[2], Yuya Yamaguchi[1], Naokatsu Yamamoto[1], Takeshi Hoshida[2], Atsushi Kanno[1]; *[1]National Inst of Information & Comm Tech, Japan; [2]Fujitsu Limited, Japan.* A complex-valued Volterra system identification method via phase retrieval is proposed as an affordable monitoring solution for generating and maintaining the dynamic true-to-life simulation model, namely digital twin, of a coherent optical component. The feasibility of the proposed digital twinning method is demonstrated numerically.

We5.24
On the Performance of Super-Symbol PCS-QAM Digital Subcarrier Multiplexing in Coherent Optical Fiber Systems, Trung-Hien Nguyen[1], Sami Mumtaz[1], Abel L. Riesgo[1], Khoa Le Trung[1], Dylan Le Gac[1], Manuel Neves[1,2], Yu Zhao[1], Yann Frignac[1], Gabriel Charlet[1], Stefanos Dris[1]; *[1]Huawei Technologies France, OCT lab., France; [2]Instituto de Telecomunicacoes, Univ. of Aveiro, Portugal.* We experimentally assess the use of super-symbol (SUP) transmission with different distribution matching methods in a 100 GBd PCS-256QAM 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.

We5.25
General-Chirp-Sequence Based Orthogonal Circulant Multiplexing for Short-Reach IM/DD Systems, Zhaoquan Fan[1], Jian Zhao[1]; [1]*South China Univ. of Technology, China.* We propose a novel general-chirp-sequence based orthogonal circulant multiplexing (OCM) that can whiten both noise and ISI across the subcarriers, and demonstrate in 117.8-Gbit/s IM/DD experiments with 10-GHz-class devices that the proposed scheme outperforms conventional OFDM, DFT-spread OFDM, OCDM and CLPS-based OCM.

We5.26
Evaluation of NGMI in 128-Gbuad PAM4 O-Band 10-km Transmission Using MLSE Based on Nonlinear Channel Estimation and Decision Feedback, Shuto Yamamoto[1], Hiroki Taniguchi[1], Akira Masuda[1], Masanori Nakamura[1], Yoshiaki Kisaka[1]; [1]*NTT Corporation, Japan.* We demonstrate 128-Gbaud PAM4 transmission with 3-dB bandwidth of 20 GHz and show that advanced MLSE schemes achieve the higher performance not only in BER but also in NGMI. The NGMI deviates from the theoretical value because a simple method is utilized for LLR calculation.

We5.27
Weighted Decision Enhanced Phase-Retrieval Receiver With Adaptive Intensity Transformation, Peijian Zhou[1], Meng Xiang[1], Gai Zhou[1], Jilong Li[1], Jianping Li[1], Songnian Fu[1], Yuwen Qin[1]; [1]*Guangdong Univ. of Technology, China.* We report a weighted decision enhanced phase-retrieval receiver with adaptive intensity transformation (WD_AIT_PR). When 56 GBaud 16QAM signals are transmitted over the 80km SSMF, the WD_AIT_PR receiver is verified to outperform other newly-reported counterparts, in terms of convergence speed, steady BER performance, and imperfections tolerance.

We5.28
Digital Pre-Distortion Based on Delta Sigma Modulation Assisted Look-up Table for Optical Transmission, Xiaobo Zeng[1], Mengfan Fu[1], Lilin Yi[1], Weisheng Hu[1], Qunbi Zhuge[1]; [1]*Shanghai Jiao Tong Univ., China.* A delta-sigma modulation assisted look-up table (LUT) in sample for transceiver nonlinear impairment is proposed, and achieves a superior performance compared with the 3-symbol LUT (LUT-3). The table size is less than 3.2% of the LUT-3 method.

We5.29
On the Impact of the Optical Phase Conjugation Solution on the Computational Complexity of Neural Network-Based Equalisers, Diego Arguello Ron[1], Karina Nurlybayeva[1], Morteza Kamalian-Kopae[1], Abdallah Ali[1], Elena Turitsyna[1], Sergei Turistyn[1]; [1]*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 SSMF, by combining midlink optical phase conjugation and pruning.

SC5 – Theory of Optical Communications – Posters

We5.30
A Parallel Structure for Polar Codes With Adaptive Frozen Set, Hamid Ebrahimzad[1], Ali Farsiabi[1], Chuandong Li[1], zhuhong zhang[1]; [1]*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 component codes.

We5.31
Generalized OSNR Penalty Induced by SDM Amplifiers' Differential Spatial-Lane Gain, Lixian Wang[1], Zhiping Jiang[1]; [1]*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 Scalable Optical Fiber Channel Modelling in Multi-Span Transmission, Yuchen Song[1], Danshi Wang[1], Qirui Fan[2], Xiaotian Jiang[1], Xiao Luo[1], Min Zhang[1]; [1]*Beijing Univ. of Post and Telecommu, China;* [2]*Department of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong.* We propose efficient modelling of optical fiber channel via NLSE-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 Borujeny[1], Frank R. Kschischang[1]; [1]*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 Liu[1], Kongni Zhu[1], Yajie Li[1], Yongli Zhao[1], Jie Zhang[1]; [1]*bupt, 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.

SC6 – Optical Transmission Systems – Posters

We5.35
Nonlinearity Mitigation in a Semiconductor Optical Amplifier Through Gain Clamping by a Holding Beam, Iosif Demirtzioglou[1], Romain Brenot[1], Abel Lorences-Riesgo[1], Trung-Hien Nguyen[1], Nayla El Dahdah[1], Antonin Gallet[1], Shuqi Yu[1], Sheherazade Azouigui[1], Yann Frignac[1], Gabriel Charlet[1]; [1]*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 Direct Detection, Tobias Prinz[1], Thomas Wiegart[1], Daniel Plabst[1], Talha Rahman[2], Md Sabbir-Bin Hossain[2], Nebojsa Stojanovic[2], Stefano Calabrò[2], Norbert Hanik[1], Gerhard Kramer[1]; [1]*Technische Universitat Munchen Fakultat fur Elektrotechnik und Informationstechnik, Germany;* [2]*Huawei 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-cross 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 Varughese[1], Daniel Semrau[1], Domanic Lavery[1], Demin Yao[1], Marc Stephens[1], Emilio Bravi[1], Mehdi Torbatian[1], Pierre Mertz[1]; [1]*Infinera 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 Banawan[1], Satyendra K. Mishra[1], Ariane Gouin[1], Nathalie Bacon[1], Xun Guan[1,2], Lixian Wang[3], Sophie Larochelle[1], Leslie Rusch[1]; [1]*Department of Electrical and Computer Engineering, Center for Optics, Photonics and Lasers (COPL), Université Laval, Canada;* [2]*Tsinghua Shenzhen International Graduate School, China;* [3]*Canada 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 Gb/s per wavelength. Our demultiplexing strategies are compatible with commercial solutions.

We5.39
Comparison of Physical Realizations of Multidimensional Voronoi Constellations in Single Mode Fibers, Ali Mirani[1], Kovendhan Vijayan[1], Shen Li[1], Zonglong He[1], Jochen B. Schroeder[1], Peter Andrekson[1], Erik Agrell[1], Magnus Karlsson[1]; *[1]Chalmers tekniska hogskola, Sweden.* We investigate experimentally and numerically the impact of using different fiber dimensions to spread out the 32-dimensional Voronoi 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[1], Xiang Lin[1]; *[1]Huawei 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[1], Noboru Yoshikane[1], Takehiro Tsuritani[1]; *[1]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
Photonically Interconnected Federated Edge-Computing Networks Using Fast Reconfigurable SOA-Based OADMs, Henrique Freire Santana[1], Rafael Kraemer[1], Ali Mefleh[1,2], Nicola Calabretta[1]; *[1]Technische Universiteit Eindhoven, Netherlands; [2]KPN, Netherlands.* We propose and demonstrate via BER tests lossless SOA-based optical add/drop multiplexer nodes for low-latency and deterministic photonically 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
O, S, C and L-Band SOA-Based OADM Nodes in Metro Networks, Rafael Kraemer[1], Henrique Freire Santana[1], Nicola Calabretta[1]; *[1]Eindhoven Univ. of Technology, Netherlands.* SOA-based O, S, C and L-band OADMs are experimentally verified for providing optical transparency between metro aggregation nodes and far-edge OLTs. Results with 28 GBd PAM-4 transmission show operation below the FEC-threshold for up to 3 nodes and 24 km of SMF in the C-band.

We5.44
A Few Milliseconds-Fast SRS-Induced Loss and Tilt Compensation Algorithm for Dynamic C+L-Band Networks, Abhishek Anchal[1], Eyal Lichtman[1]; *[1]Packet and Optical Network, Ribbon Communications, Israel.* We demostrate a ~20 milliseconds fast algorithm implemented in amplifiers for compensation of Stimulated Raman Scattering (SRS) induced loss and tilt in dynamic C+L-band networks. Simulation and lab results matche closely and thus, verify the algorithm.

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-Rok Moon[1], Sooyeon Kim[1], Eon-Sang Kim[1], Minkyu Sung[1], Changyu Choi[2], Hojin Song[2], Joon Ki Lee[1], Seung-Hyun Cho[1]; *[1]Optical Communication Research Section, Electronics and Telecommunications Research Inst., Korea (the Republic of); [2]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-Lane Interconnects, Bernhard Schrenk[1], Margareta Vania Stephanie[1]; *[1]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 Wavelength-Division Multiplexing in Deployed 5G C-RAN Front-Haul Network, Dong Wang[1], Dechao Zhang[1], Gongyuan Zhao[2], Jiang Sun[1], Youxi Lin[3], Qian Cai[1], Dawei Ge[1], Yunbo Li[1], Liuyan Han[1], Enbo Zhou[2], Xiaodong Duan[1], Han Li[1]; *[1]China Mobile Research Inst., China; [2]Huawei Technologies Co Ltd, China; [3]Huawei Technologies Deutschland GmbH, Germany.* We report the first real-time field trial of a 300Gb/s 12-channel medium wavelength-division multiplexing (MWDM) 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, Oskars Ozolins[1,2], Toms Salgals[3], Hadrien Louchet[4], Mahdieh Joharifar[2], Richard Schatz[2], Di Che[5], Yasuhiro Matsui[6], Markus Gruen[4], Thomas Dippon[4], Fabio Pittala[4], Benjamin Krueger[4], Yuchuan Fan[2], Aleksejs Udalcovs[1], Urban Westergren[2], Lu Zhang[7], Xianbin Yu[7], Sandis Spolitis[3], Vjaceslavs Bobrovs[3], Sergei Popov[2], Xiaodan Pang[2,1]; *[1]RISE Research Inst.s of Sweden AB, Sweden; [2]Kungliga Tekniska Hogskolan, Sweden; [3]Rigas Tehniska universitate, Latvia; [4]Keysight Technologies Deutschland GmbH, Germany; [5]Nokia Bell Labs, USA; [6]II-VI Inc, USA; [7]Zhejiang Univ., China.* We demonstrate an error-free 108 Gbps OOK link using a C-band externally modulated laser with 3.3 dBm of modulated output power and an O-band directly modulated laser with 7.3 dBm of modulated output power. This paves the way forward for high-speed optical interconnects without FEC.

We5.49
Highly Reliable and Large-Scale Optical Circuit Switch for Intra-Datacentre Networks, Takumi Mitsuya[1], Takuro Ochiai[1], Takuma Kuno[1], Yojiro Mori[1], Hiroshi Hasegawa[1], Ken-ichi Sato[2]; *[1]Nagoya Univ., Japan; [2]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.

We5.50
Comparison of Polybinary Shaping and Tomlinson Harashima Precoding Under Brick-Wall Bandwidth Constraint, Yixiao Zhu[1], Qunbi Zhuge[1], Weisheng Hu[1]; *[1]Shanghai Jiao Tong Univ., China.* We experimentally compare polybinary shaping and Tomlinson-Harashima precoding (THP) under 25GHz brick-wall bandwidth limitation, achieving 120%, 50% and 20% faster-than-Nyquist rates with 110Gbaud OOK, 75Gbaud PAM-4 and 60Gbaud PAM-6. Results indicate that polybinary shaping outperforms THP with OOK, while THP is better for higher-order formats.

SC9 – Photonic for RF & Free-Space Optics Applications – Posters

We5.51
SNR-Enhanced Frequency-Octupled 64QAM MM-Wave Signal Generation Using MZM-Based Angle Modulation, Zhengran Li[1], Yu Xia[1], Haiping Song[1], Mengfan Cheng[1], Qi Yang[1], Deming Liu[1], Ming Tang[1], Lei Deng[1]; *[1]Huazhong Univ. of Science and Technology, China.* We propose a novel scheme to generate the signal-to-noise-ratio (SNR)-enhanced high-order frequency multiplication millimeter-wave signals using angle modulation. An SNR-enhanced 6Gb/s 64-QAM signal with a carrier frequency of 28GHz is experimentally generated and transmitted over 25km SSMF using a 3.5GHz RF signal and 10GHz MZM.

We5.52
Demonstration of 1.75 Gbit/s VCSEL-Based Non-Directed Optical Wireless Communications With OOK and FDE, Malte Hinrichs[1,2], Giulio Boniello[1], Peter Hellwig[1], Dominic Schulz[1], Christoph Kottke[1], Martin Schubert[3], Ronald Böhnke[3], Wen Xu[3], Ronald Freund[1,2], Volker Jungnickel[1,2]; *[1]Fraunhofer Heinrich Hertz Inst., Germany; [2]Inst. of Telecommunication Systems, Technische Universitat Berlin, Germany; [3]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 m^2.

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 Bian[1], Junlian Jia[1], Zhongya Li[1], Jianyang Shi[1], Nan Chi[1,2], Junwen Zhang[1,2]; *[1]Fudan Univ., China; [2]Peng Cheng Laboratory, China.* A low-complexity multi-symbol complex-valued NN nonlinear equalizer is proposed and experimentally demonstrated in coherent photonics-assisted millimeter-wave (MMW) communication system. Significant performance improvements are observed for 100Gbps 16-QAM photonic-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 Huang[1], Zhengguo Lu[2], Ku Wu[3], Jianping Yao[1]; *[1]Univ. of Ottawa, Canada; [2]National Research Council Canada, Canada; [3]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 Zhou[1], Dhecha Nopchinda[1], Mu-Chieh Lo[1], Izzat Darwazeh[1], Zhixin Liu[1]; *[1]Univ. College London, UK.* We demonstrate sub-100fs jitter, dispersion-tolerant dissemination of 5-GHz-spaced RF tones up to 45GHz using a filtered optical frequency comb, enabling clock and RF carrier synchronised wireless communication systems with 1.4Gb/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 Vliet[1], Menno van den Hout[1], Sjoerd van der Heide[1], Chigo Okonkwo[1]; *[1]Electrical Engineering, Technische Universiteit 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.

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

We5.57
C-Band to Multi-Band Network Upgrade by a Multi-Objective Evolutionary Algorithm-Based Optimization Framework, Ruoxuan Gao[1], Yihao Zhang[1], Xiaomin Liu[1], Minggang Chen[2], Fangchao Li[2], Lilin Yi[1], Weisheng Hu[1], Qunbi Zhuge[1]; *[1]Shanghai Jiao Tong Univ., China; [2]Tencent, 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 Gumaste[1], João Pedro[1], Harald Bock[1]; *[1]Infinera 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, Takafumi Tanaka[1], Katsuaki Higashimori[1]; *[1]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 Souza[1,2], Nelson Costa[1], João Pedro[1,2], João Pires[2]; *[1]Infinera Corp, Portugal; [2]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 Optical Core Network Throughput Prediction to Large Node Scales, Robin Matzner[1], Ruijie Luo[1], Georgios Zervas[1], Polina Bayvel[1]; *[1]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 ($\rho=0.986$).

We5.62
A Novel Flexible Optical-Electrical Layer Coordinated OTN Interface With 1G Granularity Based on Probabilistic Shaping, Sheng Liu[1], Zhijun Long[2], Liangjun Zhang[2], Weiming Wang[2], Dawei Ge[1], Yuanbin Zhang[2], Dong Wang[2], Yunbo Li[1], Dong Wang[1], Minxue Wang[1], Liuyan Han[1], Dechao Zhang[1], Han Li[1], Xiaodong Duan[1]; *[1]China Mobile Research Inst., China; [2]ZTE Corp, China.* A novel OTN interface capable of fine-granularity and cross-layer hitless adjustment, facilitated by probabilistic shaping with a small step of ~1G, is proposed for the first time, which could largely increase actual capacity utilization. Correspondingly a first real-time 1G granularity probabilistic shaping is experimentally demonstrated.

We5.63
Establishing the Relationship Between GMI and SNR in Optical Networks With Nonlinear Kerr Effect, Xueying Zhong[1], Huazhi Lun[1], Mengfan Fu[1], Xiaomin Liu[1], Lilin Yi[1], Weisheng Hu[1], Qunbi Zhuge[1]; *[1]Shanghai Jiao Tong Univ., China.* We propose an artificial neural network (ANN) based algorithm to establish the mapping between generalized mutual information (GMI) and signal-to-noise ratio (SNR) in optical networks with nonlinear Kerr effect. Under highly diverse link configurations, the network achieves great performance with 0.043 dB maximum absolute error.

We5.64
A Pragmatic Power-Consumption Analysis for IPoWDM Networks With ZR/ZR+ Modules, Qiaolun Zhang[1], Annalisa Morea[2], Massimo Tornatore[1]; *[1]Politecnico di Milano, Italy; [2]Nokia, Italy.* We quantify and compare the power consumption of four IPoWDM transport network architectures employing ZR/ZR+ modules, considering different grooming, regeneration, and optical bypass capabilities. Results show that optical bypass is still the most power-efficient solution, reducing consumption by up to 30%.

We5.65
Network Authentication, Identification, and Secure Communication Through Optical Physical Unclonable Function, Pantea Nadimi Goki[1], Thomas T. Mulugeta[1], Nicola Sambo[1], Roberto Caldelli[2], Luca Poti[2,3]; *[1]Scuola Superiore Sant Anna, Italy; [2]Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Italy; [3]Universitas Mercatorum, Italy.* We propose a new method for network authentication, identification, and secure communication, using the optical photonic physical unclonable function *Challenge-Response* (PUF-CRPs) database protocol. We investigated the database performance generated with the proposed protocol by identifying 150 networks ID.

CLEO®/Europe Focus Meeting – Posters

We5.66
Designing a Digital Twin for Quantum Key Distribution, Seyed Morteza Ahmadian[1], Marc Ruiz[1], Mehmet Berkay On[3], Sandeep Kumar Singh[3], Jaume Comellas[1], Roberto Proietti[2], S. J. Ben Yoo[3], Luis Velasco[1]; *[1]Universitat Politecnica de Catalunya, Spain; [2]Politecnico di Torino, Italy; [3]Univ. of California Davis, USA.* Classical optical devices lack of precision when they operate single on photons. We report a Quantum Digital Twin (QDT) to improve Quantum Key Distribution (QKD) implementations. We show a QDT increasing the Key Exchange Rate under environmental events.

We5.67
From Intra-Datacenter Interconnects to Metro Networks: Does CV-QKD Need Loss- or Bandwidth-Conscious Receivers?, Florian Honz[1], Fabian Laudenbach[1], Hannes Hübel[1], Philip Walther[2], Bernhard Schrenk[1]; *[1]Austrian Inst. of Technology GmbH, Austria; [2]Universitat Wien Fakultat fur Physik, Austria.* We experimentally compare a loss-optimized coherent heterodyne and a bandwidth-blessed intradyne CV-QKD architecture. We find the former to prevail performance-wise for medium/long link reach, while the latter features a 5-9 dB higher secure-key rate over short reach.

We5.68
Practical Network Encryption With Quantum Cryptographic Keys, Nitin Jain[1], Erik Bidstrup[2], Hou-Man Chin[1], Hossein Mani[1], Adnan hajomer[1], Ulrik Andersen[1], Tobias Gehring[1]; *[1]Technical Univ. of Denmark, Denmark; [2]Zybersafe ApS, Denmark.* We present a state-of-the-art continuous-variable quantum cryptographic prototype that operates at 1550 nm and distributes keys across a 10 km fiber channel to network encryptors operating at 1300 nm and using the same (wavelength-multiplexed) channel for data link layer encryption.

We5.69
Characterization of the Spectral Properties of Fibre Optics Components and Devices by Use of a Filtered Supercontinuum Laser Source, Natascia Castagna[1], Jacques Morel[1]; *[1]METAS - Federal Inst. of Metrology, Switzerland.* We present 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 to rapidly growing domains like quantum communication and cryptography.

We5.70
Laser-Written Waveguide Array Optimized for Individual Control of Trapped Ion Qubits in a Chain, Timpu Flavia[1,2], Roland Matt[1], Simone Piacentini[3], Giacomo Corrielli[3], Matteo Marinelli[1,2], Cornelius Hempel[4,5], Roberto Osellame[3], Jonathan Home[1,4]; *[1]Eidgenossische Technische Hochschule Zurich Institut fur Quantenelektronik, Switzerland; [2]ETH Zürich – PSI Quantum Computing Hub, Switzerland; [3]Consiglio Nazionale delle Ricerche Istituto di Fotonica e Nanotecnologie, Italy; [4]Quantum Center, ETH Zurich, Switzerland; [5]Paul Scherrer Institut PSI, Switzerland.* We design and fabricate a waveguide array with custom mode size and pitch. We measure crosstalk values below -45 dB within the array and Gaussian emission profiles. This device enhances the performance of parallel addressing of individual ions compared to state-of-the-art methods using beam deflectors.

We5.71
Optical Properties of Aluminium Nitride on Insulator for Integrated Photonics, Jasmin Spettel[1,2], Marco Liffredo[2], Tommaso Cassese[1], Hernán Furci[2], Florian Dubois[1], Niels Quack[2,3], Mohssen Moridi[1], Guillermo Villanueva[2], Thang D. Dao[1]; *[1]Silicon Austria Labs GmbH, Austria; [2]Ecole Polytechnique Federale de Lausanne, Switzerland; [3]The Univ. of Sydney, Australia.* Aluminium nitride is a promising photonic material from the ultra-violet to the mid-infrared spectral range. We present spectroscopic ellipsometry of sputtered AlN thin films on insulator in the spectral range 0.19 µm – 25 µm, surface roughness characterization, waveguide and grating coupler designs at telecom wavelength.

We5.72
Electro-Optic Frequency Response of Thin-Film Barium Titanate (BTO) From 20 to 270 GHz, Daniel Chelladurai[1], Manuel Kohli[1], Yannik Horst[1], Marco Eppenberger[1], Laurenz Kulmer[1], Tobias Blatter[1], Joel Winiger[1], David Moor[1], Andreas Messner[1], Clarissa Convertino[2], Felix Eltes[2], Yuriy Fedoryshyn[1], Juerg Leuthold[1]; *[1]Eidgenossische Technische Hochschule Zurich Departement Informationstechnologie und Elektrotechnik, Switzerland; [2]Lumiphase AG, Switzerland.* The electro-optical frequency response of thin-film barium titanate (BTO) has been characterized in hybrid plasmonic-photonic phase shifters across the spectral range from 20 to 270 GHz. A flat frequency response was found.

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 Liang[1], Boyuan Yan[2], Jie Wu[2], Jing Wu[2], Qin Chen[2], Rui Lu[2], Lei Wang[1], Zhao Sun[1], Chongjin Xie[3]; *[1]Alibaba Cloud, Alibaba Group, China; [2]Alibaba Cloud, Alibaba Group, China; [3]Alibaba 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 Bluemm[1], Heinrich von Kirchbauer[1], Giuseppe Caruso[1,2], Pablo Leyva[3], Ullrich Wuensche[1], Rongfang Huang[1], Jinlong Wei[1], Ivan N. Cano[1], Stefano Calabrò[1], Giuseppe Talli[1]; *[1]Munich Research Centre, Huawei Technologies Duesseldorf GmbH, Germany; [2]Politecnico di Torino, Italy; [3]Citrobits 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, Lluis Gifre Renom[4], Daniel King[1], Adrian Farrel[1], Ramon Casellas[4], Ricardo Martinez[4], Juan-Pedro Fernández-Palacios[2], Oscar Gonzalez De Dios[2], José Pedreño-Manresa[3], Achim Autenrieth[3], Raul Muñoz[4], Ricard Vilalta[4]; *[1]Old Dog Consulting, UK; [2]Telefonica I+D, Spain; [3]ADVA Optical Networking SE, Germany; [4]Centre 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, Caio Santos[1], Behnam Shariati[1], Robert Emmerich[1], Carsten Schmidt-Langhorst[1], Colja Schubert[1], Johannes Karl Fischer[1]; *[1]Fraunhofer-Institut fur 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 Balanici[1], Geronimo Bergk[1], Pooyan Safari[1], Behnam Shariati[1], Johannes Karl Fischer[1], Ronald Freund[1]; *[1]Photonic Networks and Systems, Fraunhofer-Institut fur 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 Courses

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 (intradyne) 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 Romanyshyn, 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 ePIXfab
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 labautomation 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.

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/.

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.

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 Schifflände, 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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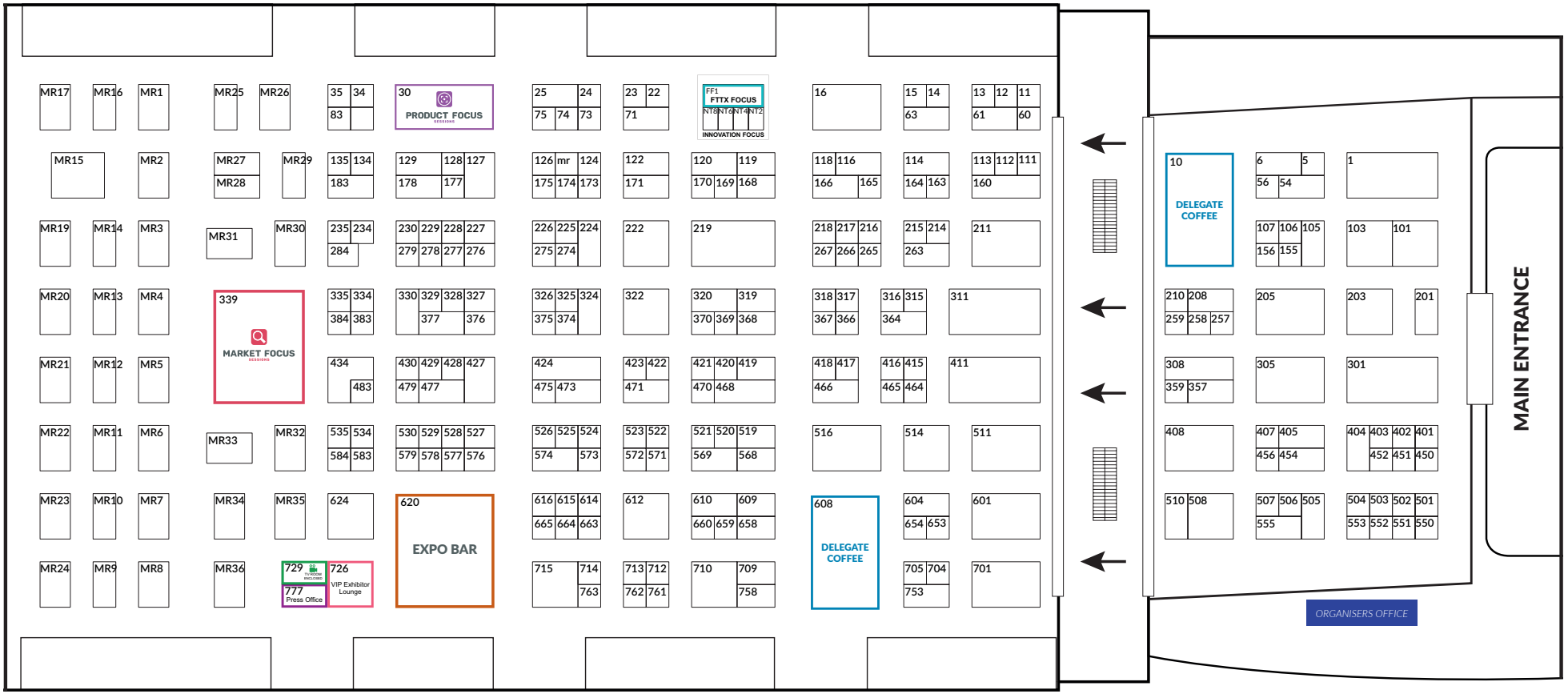


General Information

Conference Venue & Hours

Congress Center Basel
Messeplatz 21
4058 Basel
Switzerland

Sunday, 18 September, 09:00–19:00
Monday, 19 September, 09:00–18:30
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.

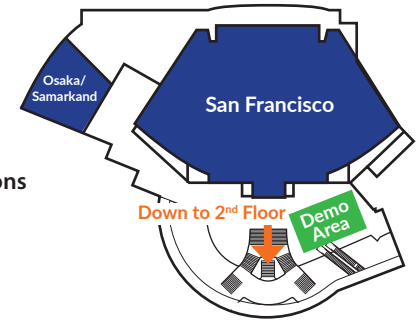
VENUE OVERVIEW ECOC Conference & Exhibition 2022 | 18-22 September 2022

CONFERENCE ROOMS - CONGRESS CENTER BASEL

3rd Floor

Plenary Sessions
- San Francisco

Conference Sessions
- Samarkand & Osaka



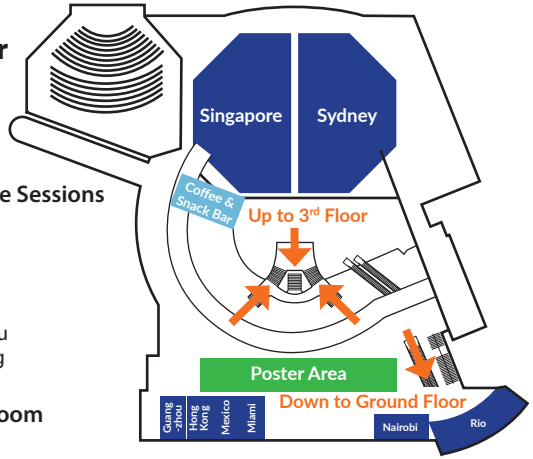
2nd Floor

Conference Sessions
- Singapore
- Sydney
- Rio

Meetings
- Guangzhou
- Hong Kong
- Mexico

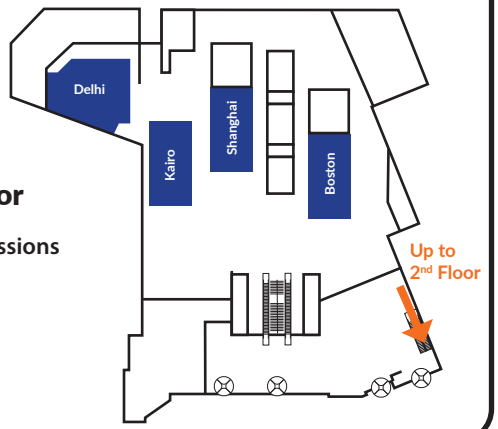
Speaker Room
- Nairobi

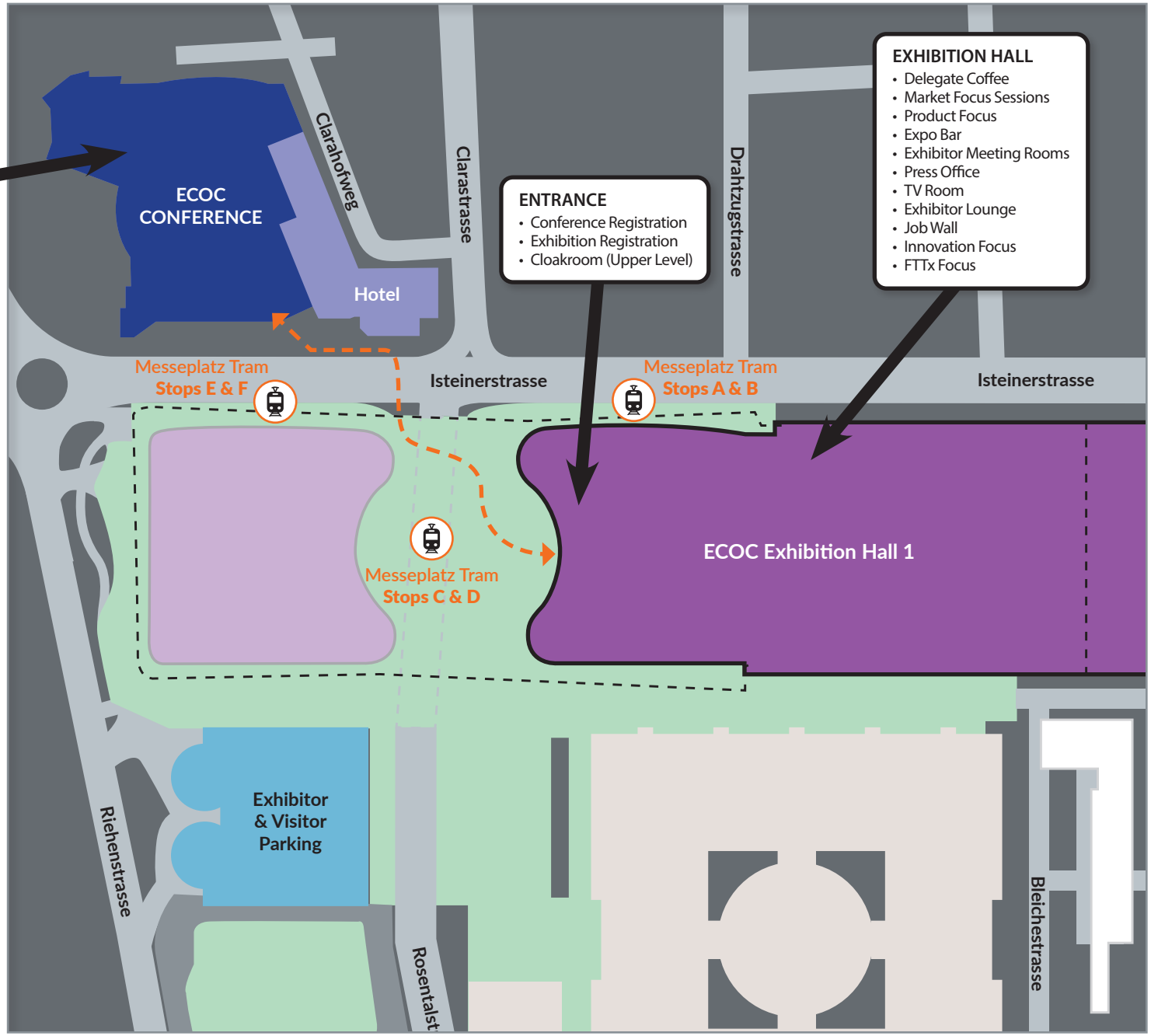
Admin
- Miami



Ground Floor

Conference Sessions
- Delhi
- Kairo
- Shanghai
- Boston





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