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Monday, 17 September 2012, 09:30 - 12:30

Auditorium

Welcome and Plenary Session

09:30 Opening Ceremony

10:00 Reaching Farther Faster By Accelerating 100G & Illuminating 400G Dr. Philippe Keryer, President Networks Group, Alcatel-Lucent, France

Broadband adoption is fast, massive, addictive and even accelerated by the explosion of new video services, smart devices and Cloud. Network consumption increases exponentially while end-users are raising the bar in terms of required quality of experience. How can Service Providers stay ahead of the curve and set up their network to drive differentiation and profitable growth? This talk will explore how breakthrough innovations in Optic networks scalability and efficiency combined with IP intelligence are at the heart of value creation in our video-intensive and cloud-enabled world.

10:30 Enabling a Borderless Lifestyle

Mr. Ruchir Rodrigues, Corporate Vice President - Product Strategy and Development, Verizon, USA

Today, the average home has seven connected devices. With the spread of LTE and the growth of M2M connections, that number will grow dramatically in the years ahead. Video is a big driver for the accelerated demand and adoption of broadband. Moving content seamlessly between connected devices is a challenge and opportunity for service providers. This talk will focus on Verizon's vision of enabling such a lifestyle for consumers.

11:00 Coffee Break, Hall 2

11:30 Quantum Dot Photonics: Past, Present and Future

Prof. Yasuhiko Arakawa, Director of Nanoelectronics Research Center, University of Tokyo, Japan

The concept of quantum dots was proposed by us for application to semiconductor lasers in 1982. In this presentation, we discuss the technological advances of quantum dot lasers in the past 30 years as well as the future outlook of quantum dot nanophotonics, including silicon photonics and photovoltaic applications.

12:00 From 40 to 100G in 63113852000 milliseconds- Gigabit Bandwidth Evolution in SURFnet Prof. Erik Huizer, Director Technology, SURFnet, The Netherlands

In the past two years SURFnet experimented to increase bandwidth from 40 to 100 Gb/s. The impact of this development on international Educational and Research networking is enormous, now enabling new high-bandwidth demanding experiments to be performed worldwide.

12:30–14:00 Lunch, on your own

	ROOM A	ROOM B	ROOM C
	14:00–15:30 Mo.1.A • Carrier & Timing Recovery (SC3) Chair: Masataka Nakazawa; University of Tohoku, Japan	14:00–15:30 Mo.1.B • Access Evolution (SC6) Chair: Stéphane Gosselin; Orange Labs, France	14:00–15:30 Mo.1.C • Undersea Systems (SC4) Chair: Ekatarina Golovchenko; <i>TE Subcom, USA</i>
14:00	Mo.1.A.1 • 14:00 pg. 1 REAL-TIME IMPLEMENTATION OF A PARALLELIZED FEEDFORWARD TIMING RECOVERY SCHEME FOR RECEIVERS IN OPTICAL ACCESS NETWORKS Daniel Schmidt', Berthold Lankl', Johannes Karl Fischer ² , Jonas Hilt', Colja Schubert ² , 'University of the Federal Armed Forces, Germany,' ² Fraunhofer Heinrich- Hertz-Institute, Germany.	Mo.1.B.1 • 14:00 Invited pg. 19 FROM HYBRID FIBRE COAX TO ALL-FIBRE NETWORKS Dean Stoneback'; <i>Motorola Mobility Inc., USA</i> . Cable operators have many options to increase throughput as they progress towards an all-fiber network, including migrating from analog to digital video,	Mo.1.C.1 • 14:00 [Invited pg. 34 25 TB/S TRANSMISSION OVER 5,530 KM USING 16QAM AT 5.2 BITS/S/HZ SPECTRAL EFFICIENCY Jin-Xing Cai ¹ , Hussam G. Batshon ¹ , Hongbin Zhang ¹ , Carl Davidson ¹ , Yu Sun ¹ , Matt Mazurczyk ¹ , Dmitri Foursa ¹ , Alexei Pilipetskii ¹ , Georg Mohs ¹ , Neal Bergano ¹ ; ¹ /TE SubCorn, USA.

Tert2-institute, Germany. Transfer rates in optical transmission systems are usually higher than the clocking speed of silicon devices. Thus parallelization has to be introduced, which means that several samples have to be processed during one operating cycle. For such a parallelized receiver structure a feedforward timing recovery scheme is implemented into an FPGA.

14:15 Mo.1.A.2 • 14:15 pg. 4 DIGITAL PLL BASED FREQUENCY OFFSET COMPENSATION AND CARRIER PHASE ESTIMATION FOR 16-QAM COHERENT OPTICAL COMMUNICATION SYSTEMS Chongjin Xie', Greg Raybon'; 'Bell Labs, Alcatel-Lucent, USA.

We modify a 2nd-order digital phase-locked loop (PLL) with additional frequency-offset compensation and pilot-symbol aided cycle slip recovery modules, and show that the modified 2nd-order PLL can successfully recover the carrier phase for a 16-QAM coherent detection system with a frequency offset up to 10% of the symbol rate.

network, including migrating from analog to digital video, increasing compression, using advanced modulation, allocating more upstream spectrum and pushing fiber deeper.

We transmit 250x100G PDM RZ 16QAM channels with We transmit 250x100G PDM RZ 16QAM channels with 5.2 bits/Hz spectral efficiency over 5,530 km using single stage C band EDFAs equalized to 40 nm. We use coded modulation and all channels are decoded with no errors after iterative decoding between a MAP and an LDPC based FEC decoder.

ORAL PAPER IDENTIFICATION Mo=day. 1=session number. A=room. 1=serial number

ROOM D

14:00-15:30

Mo.1.D • Design of Flexible & Elastic Networks (SC5) Chair: Ioannis Tomkos; Athens Information Technology Center, Greece

Mo.1.D.1 • 14:00 pg. 49 BENEFITS FOR MIXED-LINE-RATE (MLR)

AND ELASTIC NETWORKS USING FLEXIBLE FREQUENCY GRIDS Axel Klekamp¹, Ulrich Gebhard¹; ¹Bell Labs, Alcatel-Lucent, Germany.

Benefits of different channel grid configurations (ITU 50GHz grid, 12.5GHz grid, gridless) in an US network are analyzed for MLR/elastic networks, transparent network/network with high spectral efficiency, and for 2010/2020 traffic load scenarios. We show that elastic and MLR networks can achieve comparable performance levels using a 12.5 GHz grid.

Mo.1.D.2+14:15 pg. 52 NETWORK PERFORMANCE EVALUATION FOR NYQUIST-WDM-BASED FLEXIBLE OPTICAL NETWORKING Eleni Palkrons

Eleni Palkopoulou¹, Gabriella Bosco², Andrea Carena², Dimitrios Klonidis¹, Pierluigi Poggiolini², Ioannis Tomkos¹; ¹AIT, Greece; ²Politecnico di Torino, Italy.

We focus on the spectrally efficient Nyquist-WDM concept and quantify the effect of physical layer design parameters on the network level performance. Case studies are conducted on a realistic reference network under different traffic demand settings and trade-offs with respect to the utilized spectrum and the required transponders are identified

ROOM E 14:00-15:30

Mo.1.E • Transmitters (SC2) Chair: Geert Morthier; IMEC - Ghent University, Belaium

Mo.1.E.1 • 14:00 pg. 64 PARALLEL-RING-RESONATOR TUNABLE LASER PARALLEL-RING-RESONATOR TUNABLE LASER INTEGRATED WITH ELECTROABSORPTION MODULATOR FOR 100-GB/S (25-GB/S × 4) OPTICAL PACKET SWITCHING Toru Segawa', Wataru Kobayashi', Shinji Matsuo', Tomonari Sato', Ryuzo Iga', Ryo Takahashi', '*NTT* Photonics Laboratories, Japan.

We present a novel parallel-ring-resonator tunable We present a novel parallel-ing-resonator turinate laser monolithically integrated with an InGaAIAs electroabsorption modulator for 100-Gb/s optical packet switching. Clear eye openings at 25 Gb/s are achieved over a wavelength range of 25.7 nm. A dynamic extinction ratio of more than 10 dB is obtained with a constant voltage swing of 2 V at 45°C.

Mo.1.E.2 • 14:15 pg. 67 NRZ TRANSMISSION RANGE RECORD AT 40-GB/S IN STANDARD FIBER USING A DUAL ELECTRO-ABSORPTION MODULATED LASER

ABSORPTION MODULATED LASER Khalli Kechaou², Thomas Anfray³, Kamel Merghem², Christelle Aupetit-Berthelemot³, Guy Aubin², Christophe Kazmiersk¹, Christophe Jany¹, Philippe Chanclou², Didler Erasme¹, 'Communications & Electronics Department (Comelec), Institut Telecomm, Telecom Panis Tech, France; ²Laboratory for Photonics and Nanostructures, CNRS; ²Laboratory for Photonics and Insonstructures, CNRS; France; ³XLIM, University of Limoges, France; ⁴III-V Lab, Common laboratory of Alcatel-Lucent Bell Labs France', 'Thales Research and Technology' and 'CEA Leti', France; ⁵Orange Labs, France.

We demonstrate the scalability of Dual Electro-absorption Modulated Laser to higher speed and distances. The transmission reach of 40-Gb/s NRZ signal in standard fiber has been extended to a record value of 12-km with 231-1 PRBS.

ROOM F

14:00-15:30

Mo.1.F • Multicore Fibers (SC1) Chair: Tommy Geisler; OFS Fitel Denmark, Denmark

Mo.1.F.1 • 14:00 pg. 79 INVESTIGATION OF LONGITUDINAL POWER DECAY

INVESTIGATION OF LONGITUDINAL POWER DECA OF A MCF BY USING A 50-KM WEAKLY-COUPLED MULTI-CORE FIBRE Itaru Ishida', Katsuhiro Takenaga', Shoichiro Matsuo', Kunimasa Satich', Masanori Koshiba', 'Optics and Electronics Laboratory, Fujikura Ltd., Japan, 'Graduate School of Information Science and Technology, Hokkaido University, Japan.

The longitudinal power decay due to crosstalk of a weakly-coupled MCF is observed with bi-directional OTDR technique. The center core and outer cores of MCFs with hexagonal layout show the different crosstalk characteristics until the power of cores is saturated.

Mo.1.F.2 • 14:15 pg. 82 MULTI CORE FIBER WITH LARGE AEFF OF 140 MM2 AND LOW CROSSTALK Katsunori Imamura', Harumi Inaba', Kazunori Mukasa', Ryuichi Sugizaki'; *Fitel Photonics laboratory, Furukawa*

Electric co., Ltd., Japan.

Multi core fiber with large Aeff as 140 µm2 and low crosstalk less than -40 dB after 100 km transmission vas successfully developed. The design of core profile, core pitch, and cladding diameter were optimized simultaneously to achieve optical properties suitable for the future large capacity transmission utilizing the multi level signal format

AUDITORIUM

14:00-15:30

Mo.1.G • Symposium on Indoor Optical Networks: a Promising Way to a Converged

Service Delivery Chairs: Ton Koonen, COBRA - TU Eindhoven, The Netherlands; Misha Popov, ACREO, Sweden

Mo.1.G.1 pg. 94 OPENING REMARKS: STATE-OF-THE-ART OF HOME

NETWORKING Ton Koonen¹, Misha Popov²; ¹COBRA - TU Eindhoven, The Netherlands²ACREO, Sweden

To introduce the Symposium, this presentation will give a brief overview of state-of-the-art home networking architectures, technologies and applications covering both technical and techno-economic aspects.

Mo.1.G.2 N/A

HOME NETWORKS: THE GREAT UNKNOWN FOR THE SERVICE PROVIDER Frank den Hartog; TNO Telecom, the Netherlands

As new broadband access networks drive the development of new cross-sectoral services, they aevelopment of new cross-sectoral services, ney also lead to home networks increasing in size, scale, and heterogeneity. This comes at the cost of growing managerial complexity, weakening the service provide business case. An overview will be presented of the technical solution space which includes new networkand service architectures, network performance optimization, and remote-management tools, Also standardization strategies will be discussed, especially regarding the Home Gateway Initiative (HGI), an international operator-led consortium committed to shaping how broadband services are delivered to the home

Mo.1.G.3 N/A HOW TO MEET THE SERVICE NEEDS OF THE END USER? Gerlas van den Hoven; Genexis, The Netherlands

Broadband services at fiber-speeds go well beyond today's triple play. There will not be a single killer application; fiber enables the full combination of nextgeneration applications such as e-health, teleworking,

generation applications such as e-health, teleworking, smart home, gaming, interactive television, and more. The challenge is to provide user-friendly access to these services. This presentation will discuss how FTTH networking technologies such as Gigabit Point-to-Point, GPON, and beyond, can provide the broadband service needs of tomorrow's end-user.

ROOM A

ROOM B Mo.1.B • Access Evolution (SC6)—Continued

Chair: Stéphane Gosselin; Orange Labs, France

Mo.1.B.2 • 14:30 pg. 22 NONLINEAR DISTORTION AND DSP-BASED COMPENSATION IN METRO AND ACCESS NETWORKS USING DISCRETE MULTI-TONE

Weizhen Yan¹, Bo Liu¹, Lei Li¹, Zhenning Tao¹, Tomoo Takahara², Jens C. Rasmussen²; ¹*Fujitsu Research &*

Development Center, China; ²Fujitsu Laboratories Ltd.,

reduces the capacity of optical discrete multi-tone system beyond dozens of kilometers. The proposed nonlinear equalizer compensated the distortion and increased the capacity by up to 50%.

The nonlinear distortion caused by the interaction between chromatic dispersion and direct detection

14:00-15:30

Japan

ROOM C

14:00-15:30

Mo.1.C • Undersea Systems (SC4)—Continued Chair: Ekatarina Golovchenko; *TE Sub^ocom, USA*

14:00-15:30 Mo.1.A • Carrier & Timing Recovery (SC3)-Continued

Chair: Masataka Nakazawa; University of Tohoku, Japan

Mo.1.A.3 • 14:30 pg. 7 LINEWIDTH-TOLERANT AND LOW-COMPLEXITY TWO-STAGE CARRIER PHASE ESTIMATION USING QPSK CONSTELLATION TRANSFORMATION FOR 14:30

112 GB/S PM 16-QAM SYSTEMS Jian Hong Ke¹, Kang Ping Zhong¹, John C. Cartledge¹; 'Electrical and Computer Engineering, Queen's University at Kingston, Canada.

The performance of QPSK constellation transformation based two-stage carrier phase estimation algorithms is assessed for 16-ary quadrature-amplitude-modulation. Experimentally the linewidth tolerance of the algorithms is shown to be comparable to the blind phase search algorithm, but with a reduction in the complexity by factors of about 3-8.

Mo.1.A.4 • 14:45 pg. 10 TRAINING SYMBOL BASED CHANNEL ESTIMATION FOR ULTRAFAST POLARIZATION DEMULTIPLEXING IN COHERENT SINGLE-CARRIER TRANSMISSION SYSTEMS WITH M-QAM CONSTELLATIONS 14:45 Mohamed H. Morsy-Osman', Mathieu Chagnon', Qunbi Zhuge', Xian Xu', Mohammad Mousa-Pasandi', Ziad A. El-Sahn', David V, Plant', 'Electrica' & Computer Engineering, McGill University, Canada.

We propose a training symbol based algorithm that estimates the Jones channel matrix whose entries are estimates the Jones channel matrix whose entries are used as the initial center taps of a decision-directed butterfly equalizer. With fewer than 40 training symbols, we experimentally demonstrate ultrafast polarization demultiplexing for 112 Gbps PDM-QPSK and 224 Gbps PDM-16QAM systems.

Mo.1.B.3 • 14:45 pg. 25 HALF-CYCLE QAM MODULATION FOR VCSEL-BASED OPTICAL LINKS Tien-Thang Pham¹, Roberto Rodes¹, Jesper Bevensee Jensen¹, Chang-Hasnain J. Connie², Idelfonso Tafur Monroy', Department of Photonics Engineering, Technical University of Denmark, Denmark; ²Dept. of Electrical Engineering and Computer Science, University of California, Berkeley, USA.

Novel spectrally efficient half-cycle QAM modulation is experimentally demonstrated. 10 Gbps 4-QAM signal in 20 km SMF using an un-cooled 1.5 µm VCSEL with no equalization applied.

Mo.1.C.2 • 14:30 pg. 37 DEMONSTRATION OF THE MITIGATION OF INTRA-CHANNEL NONLINEARITIES BASED ON INTER-POLARIZATION DIGITAL FREQUENCY OFFSETTING WITH 50GB/S PM-QPSK SIGNAL OVER 10,080KM TRANSMISSION

Shinsuke Fujisawa¹, Takehiro Nakano², Daisaku Ogasahara¹, Emmanuel Le Taillandier de Gabory¹, Yoshihisa Inada², Toshiharu Ito¹, Kiyoshi Fukuchi¹; *Green Platform Research Laboratories, NEC* Corporation Japan²Submarine Network Division NEC Corporation, Japan.

We propose a new method to mitigate intra-channel nonlinear impairments based on digital frequency offsetting between polarizations. We experimentally demonstrate the improvement of the maximal Q-factor by 0.8 dB for 50Cb/s PM-IRZ-QPSK signal over a 10,080km PSCF transmission line with the impact of bandwidth-narrowing by 25GHz filtering.

Mo.1.C.3 • 14:45 pg. 40 6 TB/S UNREPEATERED TRANSMISSION OF 60 X 100GB/S PDM-R2 QPSK CHANNELS WITH 40 GHZ SPACING OVER 437 KM Hans Bissessur', Sophie Etienne', Philippe Bousselet², Stephane Rugger', Dominique Mongardien', 'Alcatel-Lucent Submarine Networks, France; *Alcatel-Lucent, Bell Labs France, France.

We present a 60 x 100 Gb/s unrepeatered transmission experiment at 2.5 b/s/Hz spectral efficiency over a record distance of 437 km of ultra-low loss fibre, with a high power booster and third-order Raman pumping. We also assess the penalty of 40 GHz compared to 50 GHz channel spacing.

ROOM D

14:00-15:30

Mo.1.D • Design of Flexible & Elestic Networks (SC5)—Continued Chair: Ioannis Tomkos; Athens Information Technology Center, Greece

Mo.1.D.3 • 14:30 pg. 55 ILLUSTRATION OF THE BEST SYNERGY BETWEEN GROOMING OF STATIC TRAFFIC AND ELASTIC SPECTRAL EFFICIENCY IN THE WDM NETWORKS Thierry Zami1; 1Alcatel-Lucent, France.

Within an American WDM backbone network, we identify Whilm an Antenical who backbone network, we bernin the best synergy (leading to the largest overall capacity) between grooming of static traffic and elastic spectral efficiency based on superchannels with impairment aware global optimization of regenerators placement.

Mo.1.D.4 • 14:45 pg. 58 ROUTING AND SPECTRUM ASSIGNMENT FOR SUPER-CHANNELS IN FLEX-GRID OPTICAL NETWORKS

Nicola Sambo¹, Filippo Cugini², Giulio Bottari³, Paola Iovanna³, Piero Castoldi¹; ¹Scuola Superiore Sant'Anna, Italy; ²CNIT, Italy; ³Ericsson, Italy.

Two novel routing and spectrum assignments (RSAs) are proposed for super-channels accounting for sub-carriers dynamicity. The proposed RSAs obtain low blocking probability and reduce the number of required super-transponders.

ROOM E

14:00-15:30

Mo.1.E • Transmitters (SC2)—Continued Chair: Geert Morthier; IMEC - Ghent University, Belgium

Mo.1.E.3 • 14:30 pg. 70 A 1.3-MM 4-CHANNEL × 40-GB/S LENS-INTEGRATED EA/DFB LASER ARRAY FOR OPTICAL

INTERCONNECTS Daichi Kawamura', Shigeki Makino', Kenji Kogo', Yasunobu Matsuoka', Yong Lee', Toshiki Sugawara', Shigehisa Tanaka', 'Central Research Laboratory,

Hitachi, Ltd., Japan. A1.3-µm 4-channel lens-integrated EA/DFB laser array

was developed and successfully demonstrated stable lasing operation and 40-Gb/s 3-m error-free multimode fiber transmission on all four channels.

ROOM F

14:00-15:30

Mo.1.F • Multicore Fibers (SC1)—Continued Chair: Tommy Geisler; OFS Fitel Denmark, Denmark

IND.1.F.3 • 14:30 INVIGO pg. 85 LOW-LOSS AND LARGE-A_{EFF} MULTI-CORE FIBER FOR SNR ENHANCEMENT Tetsuya Havahi¹ Tomehi¹

. On othe LIMPANCEMENT Tetsuya Hayashi¹, Toshiki Taru¹, Osamu Shimakawa¹, Takashi Sasaki, Eisuke Sasaoka¹; ¹Optical Communications R&D Laboratories, Sumitomo Electric Industries, Ltd., Japan.

We designed and fabricated a low-crosstalk seven-core fiber with losses up to 0.17 dB/km and effective areas larger than 120 µm2, and show improved performance in signal-to-noise ratio of each core of the fiber in existence of the crosstalk

Mo.1.E.4 • 14:45 pg. 73 LOW-THRESHOLD AND NARROW LINEWIDTH TWO-ELECTRODE MQW LATERALLY COUPLED DISTRIBUTED FEEDBACK LASERS AT 1550 NM List Indo TED TED BACK DACKS AT 1530 KW Kais Dridi', Ramon G. Maldonado-Basilo', Abdessamad Benhsaien', Xia Zhang', Trevor J. Hall'; 'Centre for Research in Photonics, University of Ottawa, Canada; ²CPFC-NRC, CMC Microsystems, Canada.

We demonstrate for the first time a low-threshold and narrow-linewidth multi-electrode distributed feedback laser with third-order surface gratings operating at 1550 nm. Stable single-mode operation is obtained with SMSR of over 50 dB.

AUDITORIUM

14:00-15:30

Mo.1.G • Symposium on Indoor Optical Networks: a Promising Way to Converged Service Delivery—Continued Chairs: Ton Koonen, COBRA - TU Eindhoven, The Netherlands; Misha Popov, ACREO, Sweden

Mo.1.G.4 N/A THE FUTURE OF HOME NETWORKING Anthony Ng'oma, Hejie Yang, Rich Wagner; Corning

Incorporated, USA The proliferation of smart consumer devices and of the

The proliferation of smart consumer devices and of the emerging high-bandwidth user applications has a strong impact on the requirements put on in-home networks. After performance evaluation of state-of-the-art home networking technologies used today, we have observed a significant gap between the current network performance and user requirements. In this talk, we will discuss technical challenges and key components of potential solutions that the industry should develop in order meet the desired home networking performance requirements.

Mo.1.G.5 pg. 100 MULTI-FORMAT HOME NETWORKS USING SILICA FIBRES

Ph. Guignard, J. Guillory, Ph. Chanclou, A. Pizzinat. O. Bouffant, N. Evanno, J. Etrillard, B. Charbonnier, S. Gosselin, L. Guillo, F. Richard; *Orange Labs, France* Two major challenges will drive the search for an efficient home network solution. The first one is to increase the bit rate to meet the requirements related to high interactivity and to the richness of the contents. The second one and to the incriness of the contents. The second one is to take indo account the great heterogeneity of the signals to be delivered, the home network being the convergence point of many competing worlds, such as computer, telecommunication, and consumer electronics To reach the performances required in terms of capacity and heterogeneity, slica fiber will be preferred for its low attenuation and high bandwidth. Two main architectures have been proposed for this home network. The first one is based on an active star centered on a switch able to process different types of signals. The second one is based on a passive N × N star coupler, which provides a broadcast architecture, and wavelength division within which dWDM is witch used the tops the different a broadcast architecture, and wavelength division multiplexing (WDM) is widely used to carry the different applications on specific wavelengths. This work, partly implemented within the European project ALPHA, will be carried on within the Fench collaborative project RLDO. Moreover, the French collaborative project ORIGIN wured there entired here entitied here entitied here entitied here supports these optical home architectures and focusses on the transmission of 60GHz radio signals.

ROOM A

ROOM B

14:00-15:30

ROOM C

14:00-15:30 Mo.1.A • Carrier & Timing Recovery (SC3)-

Continued Chair: Masataka Nakazawa; University of Tohoku, Japan

15:00 Mo.1.A.5 • 15:00 pg. 13 TURBO DIFFERENTIAL DECODING FAILURE FOR A COHERENT PHASE SLIP CHANNEL Andreas Bisplinghoff, Stefan Langenbach², Theodor Kupfer², Bernhard Schmauss¹; 'University of Erlangen, Germany; ²Cisco Optical GmbH, Germany.

We study the impact of stressors such as phase slips on the performance of LDPC codes with differentially encoded coherent DP-QPSK, comparing classical soft-decision decoding and iterative (turbo) differential decoding. We find that turbo decoding shows improved baseline performance but suffers from severely reduced phase slip resilience.

Mo.1.A.6 • 15:15 pg. 16 ANALOG ELECTRICAL PHASE NOISE COMPENSATION FOR COHERENT OPTICAL 15:15 RECEIVERS

Bengt-Erik Olsson¹, Christina Larsson¹, Jonas Martensson², Arne Alping¹; ¹Ericsson AB, Sweden; ²Acreo AB, Sweden.

The applicability of optical phase noise compensation In the analog electrical domain is presented and experimentally investigated. Frequency noise power density can be reduced two orders of magnitude, enabling the use of low-cost DFB lasers for advanced modulation formats like 16-QAM.

Mo.1.B • Access Evolution (SC6)-Continued Chair: Stéphane Gosselin; Orange Labs, France

Mo.1.B.4 • 15:00 pg. 28 OPTIMIZED LATTICE-BASED 16-LEVEL

OPTIMIZED LATITCE-BASED 16-LEVEL SUBCARER MODULATION FOR IM/DD SYSTEMS Krzysztof Szczerba¹, Johnny Karout², Magnus Karlsson¹, Peter A. Andrekson¹, Erik Agrell², ¹Department of Microtechnology and Nanoscience, Chalmers University of Technology, Sweden, ²Department of Signals and Systems, Chalmers University of Technology, Sweden.

We present an experimental demonstration of an optimized 16-level lattice-based single-cycle subcarrier modulation for IM/DD systems at 10 Gbps. The new format has 2.5 dB better sensitivity than single-cycle subcarrier 16-QAM and up to 1 dB better sensitivity than baseband 4-PAM at the same bit rate.

Mo.1.B.5 • 15:15 pg. 31 FULL-ASYNCHRONOUS GIGABIT-SYMMETRIC OCDMA-PON WITH SOURCE-FREE ONUS BASED

OCDMA-PON WITH SOURCE-TREE ONUS BASED ON DPSK DOWNSTREAM AND REMODULATED OOK UPSTREAM LINKS Bo Dail', Satoshi Shimizu², Xu Wang', Naoya Wada², 'School of Engineering and Physical Sciences, Heriot-Watt University, United Kingdom; 'Photonic Network System Laboratory, The National Institute of Information and Communications Technology, Japan.

We propose an asynchronous gigabit-symmetric OCDMA-PON architecture in which ONUs are source-free. We also demonstrate a duplex OCDMA system with 50 km 10 Gbit/s/user 4-user DPSK-OCDMA downstream and 50 km 10 Gbit/s/user 4-user OOK-OCDMA upstream links. Error-free transmissions are achieved in the experiment.

14:00-15:30

Mo.1.C • Undersea Systems (SC4)—Continued Chair: Ekatarina Golovchenko; TE Subcom, USA

Mo.1.C.4 • 15:00 pg. 43 EXPERIMENTAL VERIFICATION OF THE MITIGATION OF INTRA-CHANNEL NONLINEAR IMPAIRMENTS BASED ON DIGITAL SPECTRAL SHAPING WITH 50GBPS PM-IRZ-QPSK SIGNAL OVER 10,080KM TRANSMISSION

IRANSMISSION Daisaku Ogashara', Shinsuke Fujisawa', Takehiro Nakano², Emmanuel Le Taillandier de Gabory', Yoshihisa Inada', Toshiharu Ito', Kiyoshi Fukuchi', 'Green Platform Research Laboratories, NEC Corporation, Japan; 'Submarine Network Division, NEC Corporation, Japan.

We propose a method of spectral shaping at the We projose a memory of spectral shaping at the transmitter to mitigate intra-channel nonlinear impairments. Experimental results exhibit 2dB increase of the optimal launch power and nonlinear tolerance enhancement with digital spectral shaping of a 50Gbps PM-iRZ-QPSK signal generated with a high-speed DAC-based transmitter over a 10,080km link.

Mo.1.C.5 • 15:15 pg. 46 LOW COMPLEXITY NONLINEARITY COMPENSATION FOR 100G DP-QPSK TRANSMISSION OVER LEGACY

NZ-DSF LINK WITH OOK CHANNELS Takanori Inoue¹, Eduardo Mateo², Fatih Yaman², Ting Wang², Yoshihisa Inada¹, Takaaki Ogata¹, Yasuhiro Aoki¹; 'Submarine Network Division, NEC Corporation, Japan; 2NEC Laboratories America, USA,

NLC claboratorical strained, occupient of the strained of the improvement helps to counteract the nonlinear-crosstalk penalties induced by OOK channels.

15:30-16:00 Coffee Break, Hall 2

ROOM D

14:00-15:30 Mo.1.D • Design of Flexible & Elestic Networks (SC5)—Continued Chair: Ioannis Tomkos; Athens Information Technology Center, Greece

Mo.1.D.5 • 15:00 Invited pg. 61 DESIGN PLASTICITY IN ELASTIC OPTICAL NETWORK FOR UNPREDICTABLE TRAFFIC Akira Hirano'; '*NTT, Japan.*

We propose the opto-cognitive network (OCN), which provides the highest degree of design plasticity in elastic optical networks. Autonomous network optimization to adapt to unpredictable traffic demands and photonic virtualization to achieve disruption-free operation are harmonized to serve the OCN.

ROOM E

14:00-15:30

Mo.1.E • Transmitters (SC2)—Continued Chair: Geert Morthier; IMEC - Ghent University, Belgium

Mo.1.E.5 • 15:00 Invite pg. 76 QUANTUM DASH MODE LOCKED LASERS AS OPTICAL COMB SOURCES FOR OFDM SUPERCHANNELS R. Rosales', Regan Watts², Kamel Merghem¹, C. Calò¹, A. Martinez', A. Accard², F. Lelarge², Liam Barry², Abderrahim Ramdane¹; ¹LPN, CNRS, France, ²The Rince Institute, Ireland, ²III/V Lab, a joint Laboratory of "Alcatel Lucent Bell Labs" and "Thales Research &, France.

Phase locked frequency combs spanning > 1.5 THz have been generated using passively mode locked quantum dash based lasers emitting at 1.55 µm. These combs are particularly suited for future OFDM transmission systems

ROOM F

14:00-15:30

Mo.1.F • Multicore Fibers (SC1)—Continued Chair: Tommy Geisler; OFS Fitel Denmark, Denmark

Mo.1.F.4 • 15:00 pg. 88 IMPULSE RESPONSE ANALYSIS OF COUPLED-CORE 3-CORE FIBERS Roland Ryft, Rene-Jean Essiambre¹, Sebastian Randel¹, Miquel A. Mestre¹, Christian Schmidt¹, Peter Winzer¹;

Bell Labs, Alcatel-Lucent, USA.

We report the experimental impulse response of coupledore 3-core fibers and compare the results against super-mode calculations. We show that for small coupling between cores, the impulse response is dominated by core-to-core variations of the fiber parameters.

Mo.1.F.5 • 15:15 Mo.1.F.5 • 15:15 pg. 91 LOW-CROSSTALK FEW-MODE MULTI-CORE FIBER FOR HIGH-MODE-DENSITY SPACE-DIVISION MULTIPLEXING Cen Xia', Rodrigo Amezcua-Correa', Neng Bai', Enrique

Cen Xar, Rudingo Amiezcua-contear, Neing Ear, Einique Antonio-Lopez, Daniel May-Arriojo', Axel Schulzgen', Martin Richardson', Jesús Liñares', Carlos Montero², Eduardo Mateo³, Xiang Zhouć, Guifang Li'; 'CREOL, The College of Optics & Photonics, University of Central Florida, USA; 'Faculty of Physics and School of Optics and Optometry, University of Santiago de Compostela, Spain', 'NEC Labs America, USA; 'AT&T Labs-Research, USA. USA.

A seven-core few-mode multi-core fiber in which each core supports three spatial modes has been designed and fabricated. Low inter-core crosstalk is achieved with a high mode density. This fiber allows multiplexed transmission of 21 spatial modes per polarization.

AUDITORIUM

14:00—15:30 Mo.1.G • Symposium on Indoor Optical Networks: a Promising Way to Converged Service Delivery—Continued Chairs: Ton Koonen, COBRA - TU Eindhoven, The Netherlands; Misha Popov, ACREO, Sweden

Mo.1.G.6 N/A ADVANTAGES OF HIGH-SPEED PLASTIC OPTICAL FIBERS FOR HOME NETWORKING SYSTEMS

Yashiro Koike; Keio University, Japan

With the recent rapid increase of the demands for higher quality of applications in home PCs, high-definition 3D quality of applications in home PCs, high-definition 3D TVs, tablet devices, and intelligent home appliances, high bit rate home networking systems have become inevitably important. In order to fulfill these demands, Plastic Optical Fibers (POFs) are among the most promising transmission media for in-home networks, because they can offer many advantages such as great flexibility, easy handling, and high bitrate as fast as 40Gbps which can be achieved by our graded-index technology that improved the bandwidth. The next generation home networking system can be realized by the concett of "Fiber-to-the-Display", by connecting POFs directly to terminal devices in home. Details will be described in the presentation. described in the presentation.

15:30-16:00 Coffee Break. Hall 2

	ROOM A	ROOM B	ROOM C
	16:00–17:30 Mo.2.A • Waveform Generation & Characterization (SC3) Chair: Philippe Chanclou; <i>France Telecom R&D,</i> <i>France</i>	16:00–17:30 Mo.2.B • Green Access Technologies (SC6) Chair: Junichi Nakagawa; <i>Mitsubishi Electric</i> <i>Corp., Japan</i>	16:00–17:30 Mo.2.C • High-Speed Transport (SC4) Chair: Huug De Waardt; COBRA-TU Eindhoven, Netherlands
16:00	Mo.2.A.1 • 16:00 INVICED pg. 104 DYNAMIC OPTICAL ARBITRARY WAVEFORM GENERATION AND MEASUREMENT FOR ELASTIC OPTICAL NETWORKS S. J. Ben Yoo', 'Electrical and Computer Engineering, University of California at Davis, USA. We discuss dynamic OAWG and OAWM technologies as EON transceivers to generate and detect arbitrary waveforms in any modulation format across their operating bandwidth. Compared to other technologies, OAWG/OAWM provides EON with most versatility, flexibility, and optical performance monitoring capability.	Mo.2.B.1 • 16:00 pg. 119 DEMONSTRATION OF LOW-POWER BIT- INTERLEAVING TOM PON Hungkei Chow', Dusan Suvakovic', Doutje van Veen', Armaud Dupas', Roger Boislaigue', Robert Farah', Man Fai Lau', Joseph Galaro', Gin Qua', N. Prasanth Anthapadmanabhan', Guy Torfs', Christophe Van Praet', Xin Yin', Peter Vetter', ' <i>Bell Labs, Alcatel-Lucent, USA</i> ; <i>*INTEC/IMEC, Ghent University, Belgium</i> , ' <i>Bell Labs,</i> <i>Alcatel-Lucent, France.</i> A functional demonstration of bit-Interleaving TDM downstream protocol for passive optical network is reported. The proposed protocol presents a significant reduction in dynamic power consumption in the customer premise equipment over the conventional protocol. Experimental results show that more than 30x energy- saving is achievable.	Mo.2.C.1 • 16:00 IVIED pg. 134 400-GB/S/CH HIGH CAPACITY TRANSPORT TECHNOLOGIES Akhidie Sanoi, Takayuki Kobayashi', Yutaka Miyamoto'; ' <i>NTT Network Innovation Laboratories, Japan.</i> We review key technologies for 100-Tb/s-class high capacity optical transmission systems with 400-Cb/s channel rates focusing on multi-level modulation and spectrally efficient optical multiplexing, and describe pilot- assisted single-carrier frequency-division multiplexing technique.
16:15		Mo.2.B.2 • 16:15 pg. 122 A 113 GB/S (10 X 11.3 GB/S) ULTRA-LOW POWER EAM DRIVER ARRAY Renato Vaernewyck ¹ , Johan Bauwelinck ¹ , Xin Yin ¹ , Ramses Pierco ¹ , Jochen Verbrugghe ¹ , Guy Torfs ¹ , Zhisheng Li ¹ , Xing-Zhi Qiu ¹ , Jan Vandewege ¹ , Richard Cronin ² , Anna Borghesan ² , Dave Moodie ² , ¹ /1/TEC/ <i>IMEC, Ghent University, Belgium; ²CIP Technologies, United Kingdom.</i> An ultra-low power SiGe BiCMOS IC for driving a 10 channel EAM array at 113 Gb/s is presented for WDM- PON applications. The driver array consumes only 2.2 W or 220 mW per channel, 50% below the state of the art.	
16:30	Mo.2.A.2 • 16:30 pg. 107 MULTI-HARMONIC OPTICAL COMB GENERATION Simon Fabbri', Stylianos Sygletos', Andrew Ellis'; 'Photonic Systems Group, Tyndall National Institute, Ireland. We present a novel optical comb generation technique based on the use of a multi-harmonic electrical signal for driving the MZM. The proposed scheme is highly power efficient and gives rise to square shaped combs of advanced flatness and side mode supression ratio while	Mo.2.B.3 • 16:30 InviteD pg. 125 CHALLENGES FOR FUTURE ENERGY-AWARE OPTICAL ACCESS NETWORKS Junichi Kani'; 'N/TT, Japan. This paper first summarizes the current status of power saving techniques for optical access networks and highlights the remaining issues. It then discusses further challenges for realizing future energy-aware optical access networks with proposing a network configuration.	Mo.2.C.2 • 16:30 pg. 137 WOM TRANSMISSION OF 108.4-GBAUD PDM-QPSK SIGNALS (40×433.6-GB/S) OVER 2800-KM SMF-28 WITH EDFA ONLY Jianjun Yu ¹² , Ze Dong ²⁴ , Zhensheng Jia ² , Hung-Chang Chien ² , Nan Chi ³ , Xinying Li ⁵ , 27E Corp, China; ² GTE USA, USA, "Ficdan University, China; ⁴ Georgia Institute of Technology, USA. We have successfully transmitted 40×433.6-Gb/s PDM- OPSK channels at a record of 108.4-GBaud over 2800-

Ireiand. We present a novel optical comb generation technique based on the use of a multi-harmonic electrical signal for driving the MZM. The proposed scheme is highly power efficient and gives rise to square shaped combs of advanced flatness and side mode suppression ratio while maintaining a stable performance over a long time period

rectinuousy, 05A.
 We have successfully transmitted 40×433.6-Gb/s PDM-QPSK channels at a record of 108.4-GBaud over 2800-km EDFA only SMF-28 link with a BER below 3.8x10-3.
 Receiver-side digital filtering and low-complexity MLSE are introduced for the suppression of noise and linear crosstalk.

ROOM D ROOM E ROOM F AUDITORIUM 16:00-17:30 16:00-17:30 16:00-17:30 16:00-17:30 Mo.2.E • Detectors & Receivers (SC2) Mo.2.D • Control Plane Solutions for Flexible and Elastic Optical Networks (SC5) Mo.2.F • Structured Fibers (SC1) Mo.2.G • Symposium on Indoor Optical Networks: a Promising Way to Converged Chair: Joe Campbell; University of Texas, USA Chair: Hans Limberger; EPFL, Switzerland Chair: Dimitra Simeonidou; Photonic Networks Service Delivery Chairs: Ton Koonen, COBRA - TU Eindhoven, Res. Lab. Colchester, UK

Mo.2.D.1 • 16:00 pg. 149 OPERATOR PERSPECTIVE ON BROADBAND NETWORK TRAFFIC EVOLUTION Christoph Lange¹, Olaf Bonness¹, Nils Leder¹; ¹Laboratories, Deutsche Telekom AG, Germany.

In order to have a robust and reliable basis for future network extensions network operators are applying traffic analysis and forecasting methods. Two measurement series for a backbone and an access/aggregation network are discussed and it is illustrated how different methodologies are used to generate valuable conclusions for network operators.

Mo.2.D.2 • 16:15 pg. 152 DESIGNING NATIONAL IP/MPLS NETWORKS WITH FLEXGRID OPTICAL TECHNOLOGY

Luis Velasco¹, Paul Wright², Andrew Lord², Gabriel Junyent¹; ¹Computers Architecture, Universitat Politècnica de Catalunya (UPC), Spain; ²Innovate & Design, British Telecom, United Kingdom.

We propose a two-step procedure to design flexgrid-based national networks. Locations are first partitioned into a set of metro areas interconnected through a flexgrid optical network. Next, each network is designed separately. Optimal results show a future large (>200 nodes) flexgrid core network inter-connecting small (~10 nodes) metro regions.

Mo.2.D.3 • 16:30 Invited pg. 155 OPENSLICE: AN OPENFLOW-BASED CONTROL PLANE FOR SPECTRUM SLICED ELASTIC OPTICAL PATH NETWORKS Lei Liu¹, Raul Muñoz², Ramon Casellas², Takehiro

Tsuritani¹, Ricardo Martínez², Itsuro Morita¹; ¹KDDI R&D Laboratories Inc., Japan; ²Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain.

We present an OpenFlow-based control plane for spectrum sliced elastic optical path networks, called OpenSlice, for dynamic end-to-end path provisioning and IP traffic offloading. Experimental demonstration and numerical evaluation show its overall feasibility and efficiency

Mo.2.E.1 • 16:00 pg. 164 HIGH-PERFORMANCE VERTICAL-ILLUMINATION TYPE 100% GE-ON-SI PHOTODETECTORS **OPERATING UP TO 50 GB/S**

In Gyoo Kim', Ki-Seok Jang', Sanghoon Kim', Jiho Joo', Gyungock Kim', 'Convergence Components & Materials Research Laboratory, Electronics and Telecommunications Research Institute, Republic of Korea.

We present high-performance vertical-illumination type Ge-on-Si photodetectors (PDs) which are ready for optical network applications. The fabricated vertical-illumination type Ge PDs show good responsivity up to COOLINE to the second s 50Gb/s data transmission.

Mo.2.E.2 • 16:15 pg. 167 SILICA-BASED PLC WITH HETEROGENEOUSLY-INTEGRATED PDS FOR ONE-CHIP DP-QPSK

RECEIVER Yu Kurata¹, Yusuke Nasu¹, Munehisa Tamura¹, Ryoichi Kasahara¹, Shinichi Aozasa¹, Takayuki Mizuno¹, Haruki Yokoyama¹, Satoshi Tsunashiama¹, Yoshifumi Muramoto¹; ¹NTT Photonics Laboratories, NTT Corporation, Japan.

We fabricated a 1-chip DP-QPSK receiver PLC by the heterogeneous integration of eight high-speed PDs on a compact silica-based PLC platform with a PBS, 90-degree optical hybrids and a VOA. 32 Gbaud DP-QPSK signal demodulation was successfully demonstrated.

Mo.2.E.3 • 16:30 pg. 170 MONOLITHIC INP RECEIVER CHIP WITH A 90°

HYBRID AND 56CHZ BALANCED PHOTODIODES Patrick Runge', Stefan Schubert', Angela Seeger', Klemens Janiak', Jens Stephan², Dirk Trommer², Andreas Matiss², 'Fraunhofer Heinrich-Hertz-Institut, Germany; ²u²t Photonics AG, Germany.

We demonstrate a monolithically integrated quadrature coherent receiver PIC on an InP substrate with a 90° optical hybrid and two balanced 56GHz pinphotodetectors. The presented devices enable the use of 56/64Gbaud 16-QAM signals either in the C-band or the L-band

Mo.2.F.1 • 16:00 pg. 179 COMPLEMENTARY ANALYSIS OF MODAL CONTENT AND PROPERTIES IN A 19-CELL HOLLOW CORE PHOTONIC BAND GAP FIBER USING TIME-OF-FLIGHT AND S2 TECHNIQUES

David R. Gray¹, Zhihong Li¹, Francesco Poletti¹, Radan Slavík¹, Natalie Wheeler¹, Naveen K. Baddela¹, Marco N. Petrovich¹, Asiri Obeysekara¹, David Richardson¹; Optoelectronics Research Centre, University of Southampton, United Kingdom.

We study the rich multimode content of an ultra-low loss hollow core photonic bandgap fiber using two complementary techniques which allow us to investigate both short and long propagation distances. Several distinct vector modes are clearly identified, with evidence of low intermodal coupling and distributed scattering.

Mo.2.F.2 • 16:15 pg. 182 1.45 TBIT/S, LOW LATENCY DATA TRANSMISSION THROUGH A 19-CELL HOLLOW CORE PHOTONIC BAND GAP FIBRE Radan Slavik¹, Marco N. Petrovich¹, Natalie Wheeler¹

John Hayes¹, Naveen K. Badella¹, David R. Gray¹, Francesco Poletti¹, David Richardson¹; ¹Univ Southampton, United Kingdom.

We report transmission of 37 x 40 Gbit/s C-band channels over 250-m of hollow core band gap fibre, at 99.7% the speed of light in vacuum. BER penalty below 1 dB as compared to back-to-back was measured across the C-band.

Mo.2.F.3 • 16:30 pg. 185 ANALYSIS OF LIGHT SCATTERING FROM SURFACE ROUGHNESS IN HOLLOW-CORE PHOTONIC BANDGAP FIBERS

Eric Numkam Fokoua¹, Francesco Poletti¹, David Richardson¹; ¹Optoelectronics Research Centre, University of Southampton, United Kingdom.

We present a theoretical method that combines statistical information from surface roughness, mode field distribution and fibre geometry to accurately describe roughness scattering in hollow-core photonic bandgap fibres. The method predicts angular distributions of scattered power and attenuation values that agree well with experimental data.

The Netherlands; Misha Popov, ACREO, Sweden

Mo.2.G.1 pg. 194 RECENT ACHIEVEMENTS IN POF TRANSMISSION Eduward Tangdiongga, Yan Shi, Chigo Okonkwo, Henrie van den Boom, Ton Koonen; *TU Eindhoven, The* Netherlands

The potential for 'do-it-vourself' installation, eas maintenance, and high bending tolerance is driving the commercialization of large-core polymethylmetacrylate (PMMA) plastic optical fibers (POFs) for shortrange multi-gigabit transmission capacities. Record transmission rates have been achieved, by using advanced modulation formats with simple intensity-modulation direct-detection systems with low-cost and eye-safe transceivers to enable transmission over 50-m POF links. In addition, results of transmitting highcapacity baseband signals together with wireless signals such as OFDM ultra-wide band transmitted over a single POF infrastructure are presented to highlight the key potential for POF-enabled delivery of both high-speed wired and wireless services.

Mo.2.G.2 pg. 197 GIGABIT SOLUTIONS ON PMMA-POF AND THE RELATED EUROPEAN STANDARDIZATION Olaf Ziemann¹, Christian-Alexander Bunge², Roma Kruglov¹, Juri Vinogradov¹, Sven Loquai¹, Stefan Werzinger¹; ¹POF Application Center, Germany; ²Deutsche Telekom Hochschule für Telekommunii Germany

Polymer (/Plastic) Optical Fibers can be used for data transmission at bit rates of 1 Gbps and more, as has been demonstrated in many laboratories and projects been demonstrated in many laboratories and projects over the last years. The paper will give an overview of the different options for transmitters, fibers and modulation formats. Two different proposals for a standard Gigabit interface are under discussion in the German POF standardization group AK412.7.1. The main focus will be set on the use of LEDs as low-cost components and latest results using a new green (530 nm) LED for 1 Gbps transmission over 50 m SI-POF will be demonstrated.

	ROOM A	ROOM B	ROOM C
	16:00–17:30 Mo.2.A • Waveform Generation & Characterization (SC3)—Continued Chair: Philippe Chanclou; <i>France Telecom R&D</i> , <i>France</i>	16:00–17:30 Mo.2.B • Green Access Technologies (SC6)— Continued Chair: Junichi Nakagawa; <i>Mitsubishi Electric</i> <i>Corp., Japan</i>	16:00–17:30 Mo.2.C • High-Speed Transport (SC4)— Continued Chair: Huug De Waardt; COBRA-TU Eindhoven, Netherlands
16:45	Mo.2.A.3 • 16:45 pg. 110 CAVITY-LESS PULSE SOURCE BASED OPTICAL SAMPLED ADC Andreas O. J. Wibergi, Lan Liu', Zhi Tong', Evgeny Myslivets', Vahid Atale', Nicola Alic', Stojan Radic'; 'Electrical and Computer Engineering, University of Californis San Diego, USA. We propose and characterize a picosecond cavity-less optical pulse source operating at 2 GHz to be used in optical asmpling. The high quality of the pulse source was verified by measuring 8 ENOB at 10 GHz.		Mo.2.C.3 • 16:45 pg. 140 REAL-TIME 96 X 100G TRANSMISSION OVER 660 KM OF DISPERSION SHIFTED FIBER AT 50 GHZ CHANNEL SPACING Vladimir Veljanovski', Wolfgang Schairer', Juraj Slovak', Christoph Höfer', Ulrich Bauer', Sander Jansen', Dirk van den Borne', 'Nokia's Siemens Networks, Germany; *Siemens AG, Austria. We demonstrate excellent 100G transmission performance over dispersion-shifted-fiber, the most challenging of all deployed fiber types. Post-FEC erro- free performance is shown after 660 km of transmission for a fully loaded 96 x 100G transmission link.
17:00	Mo.2.A.4 • 17:00 pg. 113 REAL-TIME DIGITAL NYQUIST-WDM AND OFDM SIGNAL GENERATION: SPECTRAL EFFICIENCY VERSUS DSP COMPLEXITY Rene Schmogrow ¹ , Rachid Bouziane ³ , Matthias Meyer ¹ , Peter A. Milder ³ , Philipp Schindler ¹ , Polina Bayvel ² , Robert Killey ³ , Wolfgang Freude ¹ , Juerg Leuthold ¹ ; ¹ KIT, Germany ² Topel. of Electron. Eng., University College London, United Kingdom; ³ Carnegie Mellon University, USA. We investigated the performance of Nyquist WDM and OFDM with respect to required DSP complexity. We demonstrate Nyquist pulse-shaping requiring less resources than IFFT-based OFDM for a similar performance. Tests are performed with QPSK/16QAM in a three-carrier WDM scenario.	Mo.2.B.4 • 17:00 pg. 128 A BURST-MODE LASER DIODE DRIVER WITH BURST-BY-BURST POVER SAVING FOR 106-PON SYSTEMS Hiroshi Koizumi', Minoru Togashi', Masafumi Nogawa', Yusuke Ohtomo'; 'N/TT Microsystem Integration Laboratories, NTT Corporation, Japan. A burst-by-burst power-saving function reduces power consumption by 93% while the laser is turned off. A quick laser turn-on time of 15 ns is successfully achieved, including the power settling time. More than a 30% mask margin is obtained 50 ns after the laser turns on.	Mo.2.C.4 • 17:00 pg. 143 TRANSMISSION OF MIXED 260-GB/S PDM-16QAM AND 130-GB/S PDM-0PSK OVER 960-KM AND 4160- KM DISPERSION-MANAGED SSMF SPANS Chongjin Xie', Greg Raybon'; 'Bell Labs, Alcatel-Lucent, USA. Using pulse shaping and maximum-likelihood detection techniques, we successfully transmit a mix of 260-Gb/s PDM-16QAM and 130-Gb/s PDM-0PSK channels at a 50-GHz channel spacing over 960-km and 4160-km legacy dispersion-managed SSMF spans, respectively.

ROOM D ROOM E ROOM F 16:00-17:30 16:00-17:30 16:00-17:30 Mo.2.F • Structured Fibers (SC1)—Continued Chair: Hans Limberger; EPFL, Switzerland Mo.2.D • Control Plane Solutions for Flexible and Elastic Optical Networks (SC5)— Mo.2.E • Detectors & Receivers (SC2)-Continued Continued Chair: Joe Campbell; University of Texas, USA Chair: Dimitra Simeonidou; Photonic Networks

Res. Lab. Colchester. UK

Mo.2.D.4 • 17:00 pg. 158 EXPERIMENTAL EVALUATION OF EFFICIENT ROUTING AND DISTRIBUTED SPECTRUM ALLOCATION ALGORITHMS FOR GMPLS ELASTIC NETWORKS

Raul Muñoz¹, Ramon Casellas¹, Ricardo Martínez¹, Lei Liu², Takehiro Tsuritani², Itsuro Morita²; ¹CTTC, Spain; ²KDDI R&D Laboratories, Japan.

We present and experimentally evaluate efficient strategies in GMPLS-controlled elastic optical networks for dynamic source/PCE routing algorithms. These operate with aggregated optical spectrum information in combination with advanced distributed spectrum allocation algorithms which collect the status of all basic spectrum slots on each link.

Mo.2.E.4 • 16:45 pg. 173 HIGH-RESOLUTION WAVELENGTH DEMULTIPLEXER BASED ON A BRAGG REFLECTOR WAVEGUIDE AMPLIFIER WITH LARGE ANGULAR DISPERSION Xiaodong Gu¹, Toshikazu Shimada¹, Akihiro Matsutani¹ Fumio Koyama¹; ¹*Tokyo Institute of Technology, Japan.* We present a new type of wavelength demultiplexers based on a Bragg reflector waveguide amplifier, which provides a large angular dispersion of 1-2*/m. Benefiting from its large steering and sharp divergence angles, we record a number of resolution-points over 200 for 1 mm long devices, which is the highest number in

Mo.2.E.5 • 17:00 Invited pg. 176 DETECTING SINGLE PHOTONS USING

similar devices ever reported.

SUPERCONDUCTING NANOWIRES Andrea Fiore', Saedeeh Jahanmiri Nejad', Dondu Sahin', Giulia Frucci', Arjan Sprengers', Alessandro Gaggero', Francesco Mattioli², Roberto Leoni², Johannes Beggero, Hancson Matton, Nobero Levin, Johanne Beetz⁹, Matthias Lermer⁹, Martin Kamp⁹, Sven Hofling¹, 'Applied Physics, Eindhoven University of Technology, Netherlands² Islittut of Technoica e Nanotecnologie, Consiglio Nazionale delle Ricerche, Italy: ³Technische Physik, Universität Würzburg, Germany.

Superconducting nanowires can be used to detect single photons with very high sensitivity and speed in the near-infrared. We present recent results on single-photon detectors integrated with microcavities and waveguides for increased efficiency, and photon-number-resolving detectors based on arrays of nanowires.

Mo.2.F.4 • 16:45 pg. 188 LASER-INDUCED CRYSTALLINE OPTICAL

WAVEGUIDE ON GLASS FIBRE Xian Feng¹, Jindan Shi¹, Chung-Che Huang¹, Peh Siong Teh¹, Shaif-ul Alam¹, Morten Ibsen¹, Wei Loh¹; Optoelectronics Research Centre, University of Southampton, United Kingdom.

We report for the first time the fabrication of a novel glass ribbon fibre with laser-induced single (or quasi-single) crystalline (La,Yb)BGeO5 optical waveguide.

Mo.2.F.5 • 17:00 Invited pg. 191 METAMATERIALS DRAWN IN FIBERS

Simon Fleming¹, Alessandro Tuniz¹, Alexander Argyros¹, Boris T. Kuhlmey¹; ¹Institute of Photonics and Optical Science, School of Physics, The University of Sydney, Australia.

The extraordinary properties of metamaterials have resulted in great interest in practical means of fabricating them in useful quantities. We have adapted fibre drawing to fabricate metamaterials, demonstrating engineering of the permittivity and permeability of these metamaterials at THz wavelengths

AUDITORIUM

16:00-17:30

Mo.2.G • Symposium on Indoor Optical Networks: a Promising Way to Converged Service Delivery—Continued Chairs: Ton Koonen, COBRA - TU Eindhoven, The Netherlands; Misha Popov, ACREO, Sweden

Mo.2.G.3 N/A RECENT POF DEPLOYMENTS IN EUROPE -LESSONS LEARNED Josef Faller: Homefibre Digital Network GmbH. Austria

Distribution and consumption of content is changing Distribution and consumption of content is changing dramatically with a strong impact to existing business models around the home, covering TV, Internet, telephony and communication, smart homes and energy management as well as system design and installation. The presentation will show how optical and wireless The presentation will show how oplical and whereas services can be integrated in an optimized and cost-saving way and how a future—proof infrastructure can be achieved. This talk will report on the recent experiences of POF installations in Europe and its integration with different services such as IPTV, DVB-S over IP, integration of wireless cells (low radiation wireless clusters), as well as new installation concepts and retrofit experience. The talk will summarise the hands-on experience in the last 3-4 years from installations in Austria, Germany, Switzerland, the Netherlands, Italy, Spain, Sweden, and other European countries.

Mo.2.G.4 pg. 201 STATE-OF-THE-ART AND EMERGING MULTIMEDIA-OVER-COAX (MOCA) SOLUTIONS AND DEPLOYMENTS

Arne Ljungdahl, Jim Zhao; Actioncable, Sweden/USA The Multimedia-over-Coax Alliance (MoCA) standard is rapidly emerging as the de-facto standard for multimedia home networking. This is driven by the desire to have digital content from various sources such as DVRs. audio devices and PCs reliably available anywhere in the home using the in-home existing coaxial cable wiring. The MoCA technology coexists with other services on the coax such as cable TV, cable modern, and satellite services. This enables it to be used also as a last-mile access technology to effectively and cost efficiently use the existing coax cabling for bringing high speed IP services into the home, "GigaCoax".

	ROOM A	ROOM B	ROOM C
	16:00–17:30	16:00–17:30	16:00–17:30
	Mo.2.A • Waveform Generation &	Mo.2.B • Green Access Technologies (SC6)—	Mo.2.C • High-Speed Transport (SC4)—
	Characterization (SC3)—Continued	Continued	Continued
	Chair: Philippe Chanclou; <i>France Telecom R&D</i> ,	Chair: Junichi Nakagawa; <i>Mitsubishi Electric</i>	Chair: Huug De Waardt; COBRA-TU Eindhoven,
	<i>France</i>	<i>Corp., Japan</i>	Netherlands
17:15	Mo.2.A.5 • 17:15 pg. 116	Mo.2.B.5 • 17:15 pg. 131	Mo.2.C.5 • 17:15 pg. 146
	10-GB/S WDM OPTICALLY-CONNECTED MEMORY	EVALUATION OF ONU POWER SAVING MODES IN	DEMONSTRATION OF CASCADED IN-LINE SINGLE-
	SYSTEM USING SILICON MICRORING MODULATORS	NEXT GENERATION OPTICAL ACCESS NETWORKS	PUMP FIBER OPTICAL PARAMETRIC AMPLIFIERS IN
	Daniel Brunina', Xiaoliang Zhu', Kishore Padmaraju',	Abhishek Dixit', Bart Lannoo', Sofie Lambert', Didier	RECIRCULATING LOOP TRANSMISSION
	Long Chen ² , Michal Lipson ² , Keren Bergman'; <i>1</i> Electrical	Colle', Mario Pickavet', Piet Demeester'; 'Ghent	Zohreh Lali-Dastjerdi', Oskars Ozolins' ² , Yi An',
	Engineering, Columbia University, USA; ² Electrical and	University-/BBT, Beigium.	Valentina Cristofori', Francesco Da Ros', Ning Kan',

Lung Chen-, Michal Lipson⁴, Keren Bergman¹; 'Electrical Engineering, Columbia University, USA²: Electrical and Computer Engineering, Cornell University, USA. We report on the first silicon photonic modulator-based optically-connected memory system. An FPGA-based processor generates a 4x2.5-Gb/s WDM memory link via an array of silicon microring modulators, achieving error-free (BERs-10-12) performance using several standard line coding schemes.

We propose a new dynamic bandwidth allocation algorithm for energy efficiency in next generation optical access (NGOA) networks, and evaluate the power savings possible at the optical network unit (ONU) by applying sleep and doze modes. Sleep mode is found to be most effective for NGOA systems with burst mode traffic transmission and reception.

Valentina Cristofori', Francesco Da Ros', Ning Kan', Hao Hu', Hans Christian H. Mulvad', Karsten Rottwitt', Michael Galli', Christophe Peucheret', 'Department of Photonics Engineering, Technical University of Denmark, Demmark, 'Telecommunications Institute, Riga Technical University, Latvia.

The performance of cascaded single-pump fiber optical parametric amplifiers (FOPAs) is experimentally studied for the first time using recirculating loop transmission with 80-km dispersion managed spans. Error-free performance has been achieved over 320 km for 40 Gbit/s CSRZ-OOK and CSRZ-DPSK modulated signals.

17:30–20:30 Welcome Reception: "A Dutch Evening", Europa Foyer

ROOM D	ROOM E	ROOM F	AUDITORIUM
16:00–17:30 Mo.2.D • Control Plane Solutions for Flexible and Elastic Optical Networks (SC5)— Continued Chair: Dimitra Simeonidou; Photonic Networks Res. Lab. Colchester, UK	16:00–17:30 Mo.2.E • Detectors & Receivers (SC2)— Continued Chair: Joe Campbell; <i>University of Texas, USA</i>	16:00–17:30 Mo.2.F • Structured Fibers (SC1)—Continued Chair: Hans Limberger; EPFL, Switzerland	16:00–17:30 Mo.2.G • Symposium on Indoor Optical Networks: a Promising Way to Converged Service Delivery—Continued Chairs: Ton Koonen, <i>COBRA - TU Eindhoven,</i> <i>The Netherlands</i> ; Misha Popov, <i>ACREO, Sweden</i>
Mo.2.D.5 • 17:15 pg. 161 FLEX-GRID OPTICAL NETWORK SUPPORTING MULTICASTING AT HIGH TRANSMISSION RATES			Mo.2.G.5 N/A STATE-OF-THE-ART AND EMERGING SOLUTIONS IN OPTICAL WIRELESS COMMUNICATIONS

MULTICASTING AT HIGH TRANSMISSION RATES Nicola Sambo', Filippo Cugini², Gianluca Berrettini¹, Gianluca Meloni¹, Francesco Paolucci¹, Luca Poti²; ¹Scuola Superiore Sant'Anna, Italy; ²CNIT, Italy.

A flex-grid network supporting optical multicast controlled by PCE is presented. The experimental demonstration includes bandwidth-variable WSSs, 100/200Gb/s transmission, PM-QPSK/PM-16QAM formats, and enhanced point-to-multipoint PCEP extensions for flex-grid.

17:30–20:30 Welcome Reception: "A Dutch Evening", Europa Foyer

Germany R&D activities on optical wireless indoor-communications (OWC), driven by the proliferation of LED-based lighting, have grown significantly worldwide. The newly achieved results indicate that ordinary LEDs designed for illumination can deliver data rates up to the Gbps-range, which enables numerous local area wireless applications. Most important merits are simple protection against jamming and tapping (i.e. security, confidentiality) along with the feasibility of creating well-defined, dense communication cells. This contribution provides an overview of current solutions, particularly those using visible light, and discusses first steps towards commercialisation of high-speed systems.

Klaus-Dieter Langer; Fraunhofer Heinrich Hertz Institute, Germany

Mo.2.G.6 N/A TOWARDS ENERGY EFFICIENT IN-HOME NETWORKS AND GATEWAYS Peter Vetter', Dora van Veen', Huyn-Do Jung', Leonid Kazovsky², Tolga Ayhan²; 'Alcatel-Lucent Bell Labs, USA/S, Korea, ²Stanford University, USA

This talk will discuss design options for energy efficient in-home and in-building networks. We will also introduce several alternative approaches for the home gateway based on virtualization and quasi-passive customer premise equipment.

Mo.2.G.7 N/A GENERAL DISCUSSION AND CONCLUDING REMARKS Ton Konnen¹, Misha Popov²; ¹COBRA - TU Eindhoven, The Netherlands²ACREO, Sweden

	ROOM A	ROOM B	ROOM C
	09:00–10:30 Tu.1.A • Optical Signal Processing (SC3) Chair: Shu Namiki; National Institute of Advanced Industrial Science and Technology, Japan	09:00–10:30 Tu.1.B • TDM-PON I (SC6) Chair: Peter Vetter; <i>Alcatel-Lucent, USA</i>	09:00–10:30 Tu.1.C • Spatial Multiplexing I (SC4) Chair: Christophe Peucheret; Technical University of Denmark, Denmark
09:00	Tu.1.A.1 • 09:00 pg. 205 SIMULTANEOUS REGENERATION OF TWO 160 GBIT/S VDM CHANNELS IN A SINGLE HIGHLY NONLINEAR FIBER Ju Wang ^{1,2} , Hua Ji ¹ , Hao Hu ¹ , Hans Christian H. Mulvad ¹ , Michael Galli ¹ , Evarist Palushan ¹ , Jinlong Yu ² , Palle Jeppesen ¹ , Leif K. Oxenløwe ¹ , 'DTU Fotonik, Department of Photonics Engineering, Technical University of Denmark, Denmark, 'School of Electrical and Information Engineering, Tianjin University, China. We experimentally demonstrate simultaneous all-optical regeneration of two 160 Gbit's WDM channels in a single HNLF using fiber optical parametric amplification. Receivers ensitivities at BER of 10-9 are improved by about 2.1 dB and 4.9 dB for the two channels, respectively. The BER is not degraded by the presence of a second channel.	Tu.1.B.1+09:00 pg. 220 1:N 10G-PON OVERLAY OF GPON LINK USING BIDIRECTIONAL RAMAN AMPLIFIER Benyuan Zhu', Dave Au', Faroog Khan', Yaowen Li ² ; ' <i>OFS Labs, USA;</i> ' <i>SPD, USA.</i> We describe a novel 1: n 10G-PON overlay of GPON system using 1: n splitter and a bidirectional 10G-PON optical amplifier. We experimentally demonstrate an n=8 10G-PON overlay of GPON link with the 20-km feeder fiber and 1:32-way splitter using a bidirectional discrete Raman amplifier.	Tu.1.C.1 • 09:00 pg. 235 209-KM SINGLE-SPAN MODE- AND WAVELENGTH- MULTIPLEXED TRANSMISSION OVER HYBRID FEW- MODE FIBER Roland Ryf', Sebastian Randel', Miquel A. Mestre ¹ , Christian Schmidt', Idan H. Gnauck', Rene-Jean Essiambre ¹ , Peter Winzer ¹ , Roger Delbue ² , Peter Pupalaikis ² , Anirudh Sureka ² , Yi Sun ³ , Xinli Jiang ³ , Alan H. McCurdy ² , David W. Peckham ³ , Robert Lingle ² , 'Bell Labs, Alcatel-Lucent, USA; ² LeCroy Corporation, USA; ³ OFS, USA. We experimentally demonstrate multiple-input multiple- output transmission over a 209-km hybrid few-mode fiber span of a combined 3-space. 2, -Darization-, and 5-wavelength-division multiplex, using low-loss 3-spot mode couplers and backward-pumped distributed Raman amplification.
09:15	Tu.1.A.2 • 09:15 pg. 208 SIMULTANEOUS DUAL CHANNEL PHASE REGENERATION IN SOAS Stylianos Sygletos', Mark J. Power', Fatima C. Garcia	Tu.1.B.2 • 09:15 pg. 223 A 105KM REACH FULLY PASSIVE 10G-PON USING A NOVEL DIGITAL OLT Dayou Qian', Eduardo Mateo', Ming-Fang Huang'; 'NEC	Tu.1.C.2 • 09:15 pg. 238 MODE-DIVISION-MULTIPLEXED 3X112-GB/S DP- QPSK TRANSMISSION OVER 80 KM FEW-MODE FIBER WITH INLINE MM-EDFA AND BLIND DSP

09:1

Stylianos Sygletos¹, Mark J. Power¹, Fatima C. Ga Gunning¹, Roderick P. Webb¹, Robert J. Manning¹, Andrew Ellis¹, ¹Photonic Systems Group, Tyndall National Institute, Ireland.

NetROTan instatute, interact. For the first time we demonstrate simultaneous suppression of phase distortion on two independent 10.7 Gbit/s DPSK modulated signal wavelengths using semiconductor optical amplifiers, realizing a compact phase sensitive amplifier with low power consumption.

Laboratories America, Inc., USA.

Laborations variance, inc., USA: A truly passive long-reach 10G-TDM-PON using digital OLT is demonstrated through 105km SSMF and 1:128 splitting with 5dB margin (51dB loss budget). The analog transceivers at the ONUs still maintain low system complexity and cost.

FIBER WITH INLINE MM-EDFA AND BLIND DSP Vincent Sleiffer', Yongmin Jung', Berli Inan', Haoshuo Chen', Roy van Uden', Maxim Kuschnerov', Dirk van den Borne*, Sander Jansen', Vladimir Veljanovski', Tom Koonen', David Richardson', Shaif-ul Alam', Francesco Poletti', Jayanta Sahu', Anirban Dhar', Brian Corbetté', Richard Winfield', Andrew Ellis⁶, Huug De Waard'; 'University of Technology, Eindhoven, Netherlands; 'Optoelectronics Research Centre, United Kingdom; 'Bechnische Universität München, Germany; 'Nokia Siemens Networks GmbH & Co. KG, Germany; 'Tyndall National Institute, Ireland.

rsity

We show transmission of a 3x112 Gb/s DP QPSK modedivision-multiplexed signal up to 80km, with and without multi-mode EDFA, using blind &&6 MIMO digital signal processing. We show that the OSNR penalty induced by mode-mixing in the multi-mode EDFA is negligible.

ROOM D	ROOM E	ROOM F	AUDITORIUM
09:00–10:30 Tu.1.D • Open Flow For Optical Networks (SC5) Chair: Achim Autenrieth; ADVA AG Optical Networking, Germany	09:00–10:30 Tu.1.E - Silicon Photonics (SC2) Chair: Christian Lerminiaux; <i>Université de</i> Technologie de Troyes, France	09:00–10:30 Tu.1.F • Passive Few-Mode Fibers (SC1) Chair: Christian Schaeffer; Helmut Schmidt University, Germany	09:00–11:00 Tu.1.C • Tutorial Session I (SC2) Chair: Juerg Leuthold; Karlsruhe Institute Technology (KIT), Germany

IU.1.D.1 • 09:00 Invited pg. 250 WHY OPENFLOW/SDN CAN SUCCEED WHERE GMPLS FAILED Saurav Das¹, Guru Parulkar¹, Nick McKeown¹; ¹Stanford University, USA.

OpenFlow & Software Defined Networking (SDN) ideas offer drastically reduced complexity in the control plane, increased programmability and extensibility, and a gradual adoption path; all significant advantages over GMPLS for dynamic interaction between packet and circuit networks.

rechnologie de	noyes, mance	
Tu.1.E.1 • 09:00 DYNAMIC ROUTI	pg. 265 NG IN A FIFTH-ORDER RING	

RESONATOR SWITCH ARRAY Abhinav Rohit¹, Ripalta Stabile¹, Kevin A. Williams¹; ^alectrical Engineering, Electro-Optical Communication Group, COBRA Research Institute, Eindhoven University

of Technology, Netherlands. A bus-coupled, fifth-order ring-resonator SOI switch array A bus-coupled, introduct integresorator Sorvator and your has been designed and fabricated with integrated thin-film heaters. Optical pass-bands exceeding 110GHz are achieved with extinction ratios exceeding 30dB. Dynamic re-configuration is presented with 20 µs switching time and worst-case measured power penalty of 1dB.

Tu.1.E.2 • 09:15 pg. 268 HIGH-EFFICIENT CMOS-COMPATIBLE GRATING COPLERS WITH BACKSIDE METAL MIRROR Wissem Sfar Zaoui, Maria Félix Rosa', Wolfgang Vogel', Manfred Berroth', Jörg Butschke², Florian Letzkus², Institute of Electrical and Optical Communications Engineering (INT), University of Stuttgart, Germany; ²Institut für Mikroelektronik Stuttgart, Germany.

Mistant of minorestructure display, Germany. We present a grating coupler for efficient coupling between standard fibers and photonic integrated circuits realized in a CMOS fabrication process. The method introduces a backside metal mirror to the grating coupler without need of extensive wafer bonding. The structure exhibits high coupling efficiency of -1.6 dB near the wavelength 1550 nm.

MANIPULATION AND CONTROL OF LIGHT IN MULTIMODE FIBRES Tomas Cirment Kinter

Tomas Cizmar¹, Kishan Dholakia²; ¹School of Medicine, University of St Andrews, United Kingdom; ²School of Physics & Astronomy, University of St Andrews, United Kingdom Transmission of light within a multimode fibre introduces randomization of laser beam amplitude, phase and polarization. We discuss the importance of each of these

factors and introduce a technique allowing full analysis of the light transmission through the multimode fibre and subsequent beam-shaping using a spatial light modulator.

of

Tu.1.G.1 • 09:00 Tutorial pg. 295 SINGLE-CHIP INTEGRATED TRANSMITTERS AND RECEIVERS

Larry Coldren^{1,2}, Mingzhi Lu¹, Leif Johansson¹, Mark Rodwell¹, John Parker¹, ¹*ECE*, *University of California*, *Santa Barbara*, USA; ²Materials, UCSB, USA.

Efforts to integrate numerous photonic components on a single chip have led to significant advancements over the past few years. Not only has the size, weight and power dissipation of transmitter and receiver sub-systems improved, but now photonic integration is demonstrating truly new capabilities, enabling functionalities not possible with discrete implementations. Also, sub-syte performance and cost are proving to be competitive, even where discrete implementations are possible.

Larry A. Coldren is the Kavli Professor of Optoelectronics at UCSB. Following his Ph.D. from Stanford, he spent at UCSB. Following his Ph.D. from Stanford, he spent 13 years at Bell Labs, and joined UCSB in 1984, where he is on the ECE and Materials faculties. At UCSB his work on multiple-section lasers led to his invention of the widely-tunable multi-element mirror laser, now used in numerous commercial products. Seminal contributions to efficient VCSELs also emerged. He co-founded both VCSEL and widely-tunable integrated transmitter companies that were successfully acquired. His group continues efforts on high-performance PICs and high-speed VCSELs. He has contributed to numerous papers, books and patents, He is a Fellow of the IEEE. OSA, and books and patents. He is a Fellow of the IEEE, OSA, and IEE, a recipient of the Tyndall and Kressel Awards, and a member of the National Academy of Engineering.

ROOM A

ROOM B

09:00-10:30 Tu.1.A • Optical Signal Processing (SC3)-

Continued Chair: Shu Namiki; National Institute of Advanced Industrial Science and Technology, Japan

Tu.1.A.3 • 09:30 pg. 211 MULTILEVEL AMPLITUDE AND PHASE REGENERATION IN A NONLINEAR AMPLIFYING LOOP MIRROR WITH A PHASE-SENSITIVE AMPLIFIER Tobias Roethlingshoefer^{1,2}, Georgy Onishchukov^{1,3},

Iobias Koethingshoeter^{1-,} Georgy Onishchukov^{1-,} Bernhard Schmauss^{2-,} (Gerd Leuch²⁻); ¹Max Planck Institute for the Science of Light, Germany; ¹Institute of Optics, Information and Photonics, University of Erlangen-Nuremburg, Germany; ³Erlangen Graduate School in Advanced Optical Technologies (SAOT), Germany; ⁴Chair for Microwave Engineering, University of Erlangen-Nuremburg, Germany.

A novel regenerator scheme for all-optical multilevel simultaneous amplitude and phase noise suppression is proposed. For a star-8QAM signal, consisting of two amplitude and four phase states, EVM reduction is 4 dB and 2.5 dB for the high- and low-power states, respectively. The limiting effects of the regenerator performance have been considered.

09:45

09:30

Tu.1.A.4 • 09:45 pg. 214 ALL-OPTICAL 50-GBAUD/S THREE-INPUT HYBRID ADDITION/SUBTRACTION OF QUATERNARY BASE NUMBERS USING MULTIPLE NON-DEGENERATE FWM PROCESSES AND 100-GBIT/S DQPSK FWM PRO

SIGNALS Jian Wang¹², Jeng-Yuan Yang², Hao Huang², Alan Willner², ¹Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, China; ²Department of Electrical Engineering, University of Southern California, USA.

We propose and demonstrate all-optical three-input We propose and demonstrate aii-optical three-input quaternary hybrid addition/subtraction using non-degenerate FWM processes in an HNLF and DQPSK signals. When employing 100-6bit/s RZ-DQPSK signals (A, B, C), we achieve 50-Gbaud/s three-input quaternary addition/subtraction (A+B-C, A+C-B, B+C-A) with power penalties less than 6 dB at a BER of 10-9. Tu.1.B • TDM-PON I (SC6)—Continued Chair: Peter Vetter; Alcatel-Lucent, USA

09:00-10:30

Tu.1.B.3 • 09:30 Invited pg. 226 LATEST PROGRESS OF BURST-MODE TRANSCEIVER FOR 10G-EPON Satoshi Yoshima', Masaki Noda', Naoki Suzuki', Satoshi Shirai', Daisuke Mita', Susumu Ihara', Tu.1.B.3 • 09:30 Invited

Masamichi Nogami¹, Hiroshi Aruga¹, Junichi Nakagawa¹; ¹Information Technology R&D center, Mitsubishi Electric Corporation, Japan.

We review the latest progress of burst-mode transceivers for 10G-EPON. The OLT XFP with fast/slow self-switching AGC and ONU SFP+ transceivers can achieve a loss budget of 35.9dB and a fast synctime of 240ns, which can realize 256-split with 15km transmission.

ROOM C

09:00-10:30 Tu.1.C • Spatial Multiplexing I (SC4)-Continued Chair: Christophe Peucheret; Technical University of Denmark, Denmark

Tu.1.C.3 • 09:30 pg. 241 IMPACT OF MODE COUPLING ON THE MODE-DEPENDENT LOSS TOLERANCE IN FEW-MODE FIBER TRANSMISSION

Adriana P. Lobato Polo¹, Filipe Ferreira², Maxim Kuschnerov³, Dirk van den Borne³, Sander Jansen³, Bernhard Spinnle³, Berthold Lankl¹; ¹University of Federal Armed Forces Munich, Germany; 2Nokia Siemens Networks Portugal S.A., Portugal; ³Nokia Siemens Networks GmbH & Co. KG, Germany.

In this work the impact of mode-dependent loss (MDL) from optical amplifiers in few-mode fibers with weak and strong mode coupling is analyzed. For a 409-Gbit/s 3MDM-DP-QPSK system it is shown that strong mode coupling reduces the impact of MDL in a similar manner polarization-dependent loss is reduced by polarization-mode dispersion.

Tu.1.C.4 • 09:45 pg. 244 INTER-MODAL NONLINEAR INTERACTIONS BETWEEN WELL SEPARATED CHANNELS IN SPATIALLY-MULTIPLEXED FIBER TRANSMISSION Rene-Jean Essiambre¹, Roland Ryf¹, Miquel A. Mestre¹, Alan H. Gnauck¹, Robert Tkach¹, Andy Chraplyvy¹, Sebastian Randel¹, Yi Sun², Xinli Jiang², Robert Lingle²; ¹Optical System and Networks Research, Bell Labs, Alcatel-Lucent, USA; 2 Optical Fiber Solutions, USA.

We demonstrate a new manifestation of the optical Kerr effect in multimode fibers. We show that nonlinear distortions between spatial modes of multimode fibers can be larger for channels that are well separated in wavelength than for channels in close proximity.

ROOM D

09:00-10:30 Tu.1.D • Open Flow For Optical Networks (SC5)—Continued Chair: Achim Autenrieth; ADVA AG Optical Networking, Germany

Tu.1.D.2 • 09:30 pg. 253 EXPERIMENTAL EVALUATION OF EXTENDED OPENFLOW DEPLOYMENT FOR HIGH-PERFORMANCE OPTICAL NETWORKS Mayur Channegowda', Pawel Kosteck', Nikolaos Efstathiou', Siamak Azodolmolky', Reza Nejabati, Pawel

Listeninov, Johnson Actooninov, J. Veza Peter Elbers², Maczmarek², Achim Autennieth², Jorg-Peter Elbers², Dimitra Simeonidou¹; ¹School of Computer Science and Electronic Engineering, University Of Essex, United Kingdom; ²ADVA Optical Networking, Germany. Hybrid GMPLS-OpenFlow and novel Extended

OpenFlow approaches are presented and experimentally evaluated on a converged packet and circuit switching setup. Extended OpenFlow agents, controllers and network application are developed & their performance evaluated on commercial ROADMs for the first time.

Tu.1.D.3 • 09:45 pg. 256 EXPERIMENTAL DEMONSTRATION OF AN OPENFLOW/PCE INTEGRATED CONTROL PLANE FOR IP OVER TRANSLUCENT WSON WITH THE ASSISTANCE OF A PER-REQUEST-BASED DYNAMIC

ASSISTANCE OF A PER-REQUEST BASED OTIVAN TOPOLOGY SERVER Lei Liu', Ramon Casellas', Takehiro Tsuritani', Itsuro Monta', Ricardo Martínez', Raul Muñoz'; 'KDDI R&D Laboratories Inc., Japar, 'Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain.

A seamless OpenFlow/PCE integrated control plane for IP over translucent WSON is presented via a per-request-based dynamic topology server. The overall feasibility and performance metrics of this integrated control plane are experimentally verified and quantitatively evaluated.

ROOM E

09:00-10:30

Tu.1.E • Silicon Photonics (SC2)—Continued Chair: Christian Lerminiaux; Université de Technologie de Troyes, France

Tu.1.E.3 • 09:30 Invited pg. 271 HIGH SPEED SILICON-BASED OPTICAL

HIGH SPEED SILICON-BASED OPTICAL MODULATORS Graham Reed', F.Y. Gardes', D.J. Thomson', S. Liu', P. Petropoulos', J-M. Fédéli[®], L. O'Faolain', Kapil Debnath' T.F. Krauss⁹, L. Lever', Z. Klonic' and R. W. Kelsall'; 'EOS/ORC, University of Southampton, UK; ² CEA-LETI, Minatec, CEA-Grenoble, France; ³School of Physics & Astronomy, University of St Andrews, UK; 'Institute of Microwaves and Photonics, University of Leeds, UK. In the last 8 years carrier depletion modulators have become the mainstream high data rate building block for high performance silicon photonics link. In this work We describe carrier depieton MZI and ring modulators, cavity structures for modulation enhancement and QCSE modulators, all of which are under development as part of the UK Silicon Photonics project and the European HELIOS project.

ROOM F

09:00-10:30 Tu.1.F • Passive Few-Mode Fibers (SC1)-Continued

Chair: Christian Schaeffer; Helmut Schmidt University, Germany

Tu.1.F.2 • 09:30 pg. 283 DMD FREE TRANSMISSION LINE COMPOSED OF TMFS WITH LARGE EFFECTIVE AREA FOR MIMO PROCESSING

Ryo Maruyama¹, Nobuo Kuwaki¹, Shoichiro Matsuo¹, Kiminori Sato¹, Masaharu Ohashi²; ¹*Fujikura.LTD, Japan*; ²Graduate School of Engineering, Osaka prefecture University, Japan,

We fabricated two-mode fibers (TMFs) having the opposite sign of differential modal group delay (DMD) and DMD slope. Fabricated TMFs have over 150 µm*2 Aeff and the transmission line composed of the TMFs has within [3] ps/km DMD at C+L-band.

Tu.1.F.3 • 09:45 pg. 286 LARGE-EFFECTIVE-AREA UNCOUPLED FEW-MODE MULTI-CORE FIBER

Yusuke Sasaki¹, Katsuhiro Takenaga¹, Ning Guan¹, Shoichiro Matsuo¹, Kunimasa Saitoh², Masanori Koshiba², ¹Optics and Electronics Laboratory, Fujikura Ltd., Japan; ²Graduate School of Information Science and Technology, Hokkaido University, Japan.

Characteristics of few-mode multi-core fiber were numerically analyzed and experimentally confirmed. Fabricated fibers supported two-mode transmission over C-band and L-band. The crosstalks of the fibers were estimated to be smaller than -30 dB at 1550 nm after 100-km propagation.

AUDITORIUM

09:00-11:00

Tu.1.G • Tutorial Session I (SC2)—Continued Chair: Juerg Leuthold; Karlsruhe Institute of Technology (KIT), Germany

ROOM A

Continued Chair: Shu Namiki; National Institute of Advanced Industrial Science and Technology, Japan

Tu.1.A • Optical Signal Processing (SC3)-

10:00 Tu.1.A.5 + 10:00 TV/Ied pg. 217 RECENT ADVANCES IN ULTRA-HIGH-SPEED OPTICAL SIGNAL PROCESSING Hans Christian H. Mulvad', Evarist Palushani', Hao Hu', Hua J', Michael Galili', Anders T. Clausen', Palle Jeppesen', Leff K. Oxenlawei', 'DTU Fotorik, Descrete de Oktorici, Consistenci and Totorical

Department of Photonics Engineering, Technical University of Denmark, Denmark.

We review recent advances in the optical signal We review recent advances in the optical signal processing of ultra-high-speed serial data signals up to 1.28 Tbit/s, with focus on applications of time-domain optical Fourier transformation. Experimental methods for the generation of symbol rates up to 1.28 Tbaud are also a cable-

09:00-10:30

Continued

described.

ROOM B

ROOM C

09:00-10:30 Tu.1.C • Spatial Multiplexing I (SC4)— Continued

Chair: Christophe Peucheret; Technical University of Denmark, Denmark

Tu.1.C.5 • 10:00 **Invited** pg. 247 ADVANCES IN TRANSMISSSION OVER A FEW MODES FIBER : STATE OF THE ART AND RESEARCH RESULTS.

Ezra Ip1; 1NEC Laboratories America, USA We investigate the design of erbium-doped fiber

amplifiers for few-mode fiber supporting two mode groups at the signal wavelength. We investigate the achievable gain region, gain equalization and system sensitivity to pump perturbations.

10:15

09:00-10:30 Tu.1.B • TDM-PON I (SC6)—Continued Chair: Peter Vetter; Alcatel-Lucent, USA

Tu.1.B.4 • 10:00 pg. 229 OVER 60KM TRANSMISSION EXTENDED REACH 10G-EPON SYSTEM WITH A WIDE 29DB DYNAMIC RANGE BURST-MODE RECEIVER Susumu Ihara', Satoshi Yoshima', Daisuke Mita', Masaki Noda', Masamichi Nogami', Junichi Nakagawa'; 'Information technology R&D center, Mitsubishi Electric corporation, Japan.

corporation, Japan.

We investigated the extended 10G-EPON system which has wide coverage area. Due to wide 29dB dynamic range and low dispersion penalty of 10.3G optical transceiver, we realized the 10G-EPON system which has the wide transmission area over 60km.

Tu.1.B.5 • 10:15 pg. 232 A 10GB/S APD-BASED LINEAR BURST-MODE RECEIVER WITH 31DB DYNAMIC RANGE FOR REACH-EXTENDED PON SYSTEMS Xin Yin', Bart Moeneclaey', Xing-Zhi Qiu', Jochen Verbrugghe', Koen Verheyen', Johan Bauwelinck', Jan Vandewege', Mohand Achouche', Frank, Y. Chang'; 'I/ITEC-IMEC, UGENT, Belgium,''II/V Lab, France; 'Vitesse Semicanductor Corporation, USA.

We present a first high performance APD-based linear burst-mode receiver (BM-RX) with a record wide dynamic range of 31dB. The APD multiplication factor is controlled from burst to burst within 60ns by an on-chip self-generated M-control signal.

10:30-11:00 Coffee Break, Hall 2 11:00-12:30 Exhibition Only, Hall 1

12:30-14:00 Lunch, on your own

ROOM D ROOM E 09:00-10:30 09:00-10:30 09:00-10:30

Tu.1.D • Open Flow For Optical Networks (SC5)—Continued Chair: Achim Autenrieth; ADVA AG Optical Networking, Germany

Tu.1.D.4 • 10:00 pg. 259 EXPERIMENTAL DEMONSTRATION OF OPENFLOW-ENABLED MEDIA ECOSYSTEM ARCHITECTURE FOR HIGH-END APPLICATIONS OVER METRO AND CORE NETWORKS

NEIWORKS Okung-Dike Ntofon¹, Mayur P. Channegowda¹, Nikolaos Efstathiou¹, Mehdi Rashidi Fard¹, Reza Nejabati¹, David K. Hunter¹, Dimitra Simeonidou¹; *ICSEE Department, University of Essex, United Kingdom.*

An architecture that enables inter-working relationships between the entities in a networked media infrastructure enabled test-bed is demonstrated and results of evaluations carried out are reported.

Tu.1.D.5 • 10:15 pg. 262 OPENFLOW-BASED FLEXIBLE OPTICAL NETWORKS WITH ENHANCED MONITORING FUNCTIONALITIES

Francesco Paolucci¹, Filippo Cugini², Nasir Hussain¹, Francesco Fresi¹, Luca Poti²; ¹Scuola Superiore Sant'Anna, Italy; ²CNIT, Italy.

We report the first experiment of the OpenFlow architecture in flexible optical networks. Effective control of transmission performance is demonstrated through integrated correlation of statistics and monitoring information.

Tu.1.E • Silicon Photonics (SC2)—Continued Chair: Christian Lerminiaux; Université de Technologie de Troyes, France

Tu.1.E.4 • 10:00 pg. 274 11-GBPS 80-KM TRANSMISSION PERFORMANCE OF ZERO-CHIRP SILICON MACH-ZEHNDER MODULATOR

MODULATOR Kazuhiro Gol', Kenji Oda', Hiroyuki Kusaka', Yoshihiro Terada', Kensuke Ogawa', Tsung-Yang Liow², Xiaoguang Tu², Guo-Olang Lo², Dim-Lee Kwong²; I*Fujikura Ld., Japan;* ²Institute of Microelectronics, Singapore. Zero-chirp operation of silicon Mach-Zehnder modulator is achieved in 11.1-Gbps on-off keying and 22.3-Gbps binary phase-shift keying. Low-dispersion-penalty binary processing to the second second period of the second second period of the second secon

Tu.1.E.5 • 10:15 pg. 277 CHARACTERIZATION OF THE CHIRP OF SILICON OPTICAL MODULATORS

Sheng Liu¹, David Thomson², Periklis Petropoulos¹, Frederic Gardes², Graham Reed², Jean-Marc Fedeli³; Teutin Gardes, Johanam Record, Jean-March Feder, 'Optoelectronics: Research Centre, University of Southampton, United Kingdom, 'School of Electronics and Computer Science, University of Southampton, United Kingdom, 'SCEA, LETI, France.

The chirp of a fast silicon optical modulator is characterized in this paper. Two diagnostic methods, frequency resolved optical gating and optical modulation analysis, are employed respectively. We demonstrate that the outputs of silicon optical modulators have very small intrinsic chirps across the modulated pulses

ROOM F

Tu.1.F • Passive Few-Mode Fibers (SC1)-Continued

Chair: Christian Schaeffer; Helmut Schmidt University, Germany

Tu.1.F.4 + 10:00 pg. 289 FEW-MODE PHOTONIC CRYSTAL FIBRE FOR WIDEBAND MODE DIVISION MULTIPLEXING

WIDEBAND WOLL CONTRANSMISSION TRANSMISSION Takayoshi Mori', Taiji Sakamoto', Masaki Wada', Takashi Mabudomo Hanzawa', Kyozo Yamamoto', Lin Ma', Nobutomo Hanzawa', Kyozo Tsujikawa', Shigeru Tomita'; '*NTT Access Network* Service Systems Laboratories, NTT Corporation, Japan.

We show numerically that photonic crystal fibre (PCF) can control the mode number over a wide wavelength range while realizing a large effective area and a low bending loss. We also fabricated a PCF and realized a large effective area with 2-mode operation over the S-L band experimentally.

Tu.1.F.5 • 10:15 pg. 292 METHOD TO VISUALISE AND MEASURE INDIVIDUAL MODES IN A FEW MODED FIBRE

Ian Giles¹, Asiri Obeysekara^{2,1}, Francesco Poletti², David Richardson²; ¹*Phoenix Photonics Ltd., United* Kingdom; ²Optoelectronics Research Centre, University of Southampton, United Kingdom.

Coupling between the propagating modes and radiation modes of a FMF enables separation and measurement of the properties of the light in each mode independently. A method using prism coupling from a side-polished fibre is described to access and select individual modes.

AUDITORIUM

09:00-11:00 Tu.1.G • Tutorial Session I (SC2)—Continued Chair: Juerg Leuthold; Karlsruhe Institute of Technology (KIT), Germany

Tu.1.G.2 • 10:00 Tutorial QUANTUM PHOTONICS N/A

Jeremy O'Brien¹; ¹Centre for Quantum Photonics, University of Bristol, United Kingdom.

Quantum information science promises profoundly disruptive information and communication technologies. Photons are ideal carriers of quantum information: Their low noise, high speed transmission, and ease of manipulation at the single photon level make them indispensable for quantum communication, which offers security based on the laws of physics, quantum metrology, which promises the ultimate precision measurements, and quantum information processing which promises exponentially greater computational power for particular tasks. Recently integrated optical devices have been applied to these technologies. We give an overview of quantum technologies and progress towards their realisation in integrated optics.

O'Brien is director of the Centre for Quantum Photonics. University of Bristol. His Ph.D. from the University of New South Wales in 2002 was for experimental work on correlated and confined electrons in organic conductors, superconductors and semiconductor nanostructures and progress towards silicon quantum computing. At the University of Queensland (2001-2006) he worked on quantum optics and quantum information science with photons. CQP's efforts are focused on the fundamental and applied quantum mechanics at the heart of quantum information science and technology, from prototypes for scalable quantum computing to quantum communication, and quantum metrology.

10:30-11:00 Coffee Break, Hall 2 11:00-12:30 Exhibition Only, Hall 1 12:30-14:00 Lunch, on your own

ROOM A	ROOM B	ROOM C
14:00–15:30 Tu.3.A • Optical Switching (SC3) Chair: Ernesto Ciaramella; Scuola Superiore Sant'Anna, Italy	14:00–15:30 Tu.3.B • TDM PON II (SC6) Chair: Patrick lannone; <i>AT&T, USA</i>	14:00–15:15 Tu.3.C • Spatial Multiplexing II (SC4) Chair: Polina Bayvel; <i>University College London,</i> <i>UK</i>
Tu.3.A.1 • 14:00 pg. 327 EXPERIMENTAL DEMONSTRATION OF A PDM QPSK REAL-TIME BURST MODE COHERENT RECEIVER IN A PACKET SWITCHED NETWORK Francesco Vacondio', Christian Simonneau', Adrian Voicila', Jean-Marc Tanguy', Guilhem de Valicourt', Eric Dutisseuil', Laurence Lory', Jean-Christophe Antona', Gabriel Charlet', Sebastien Bigo'; ' <i>Alcatel Lucent Bell Labs, France</i> . We achieve full real-time operation of 28 Gb/s burst- mode PDM-QPSK coherent receiver capable of handling packet-to-packet jitter and polarization wandering. The receiver is demonstrated with subwavelength switching in a four-node WDM optical packet network testbed.	 Tu.3.B.1 • 14:00 pg. 342 26-GBPS PON TRANSMISSION OVER 40-KM USING DUDBINARY DETECTION WITH A LOW COST 7-GHZ APD-BASED RECEIVER Doutije van Veen', Vincent E. Houtsma', Peter Winzer², Peter Vetter'; <i>Bell Labs, Alcatel-Lucent, USA;</i> ²<i>Bell Labs,</i> <i>Alcatel-Lucent, USA.</i> 26-Gbps serial transmission over 40-km is demonstrated for downstream PON. Duobinary detection allows for a 7-GHz APD receiver at the ONU. Transmission at this rate enables future 100G-EPON in a cost effective way using 4x25.8-Gbps TWDM. 	Tu.3.C.1 • 14:00 INVIGE pg. 357 DIGITAL SIGNAL PROCESSING IN SPATIALLY- MULTIPLEXED COHERENT COMMUNICATION Sebastian Randel, Miquel A. Mestre, Roland Ryf, Peter J. Winzer, <i>Bell Labs, Alcatel-Lucent, USA</i> Based on recent experimental results for spatially multiplexed transmission, we analyze the impulse response matrix of few-mode fiber links that support the propagation of LP01 and LP11 modes over up to 1,200- km. We characterize the channel's modal delay spread and mode-dependent loss.
Tu.3.A.2 • 14:15 pg. 330 FAST WAVELENGTH SWITCHING 112GB/S COHERENT BURST MODE TRANSCEIVER FOR DYNAMIC OPTICAL NETWORKS Robert Maher ^{1,2} , David S. Millar ¹ , Seb Savory ¹ , Benn Thomsen'; 'Electronic & Electrical Engineering, University College London, United Kingdom; ² The RINCE Institute, Dublin City University, Ireland. Using commercially available semiconductor tunable lasers with SOA blanking and pre-emphasis, we demonstrate fast synchronous switching of a multichannel 112Gb/s DP-QPSK burst mode transceiver in an 8-channel 240km DWDM optical link with 200ns reconfiguration time	Tu.3.B.2 • 14:15 pg. 345 EXPERIMENTAL DEMONSTRATION OF AN INCOHERENT TOM-PON WITH 30 GB/S D&PSK DOWNSTREAM AND 10 GB/S OOK UPSTREAM DATA Nikolaos Sotiropoulos', Ton Koonen', Huug De Waardt'; 'Electrical Engineering, Eindhoven University of Technology, Netherlands. Bidirectional transmission of 30 Gb/s D&PSK (downstream) and 10 Gb/s OOK (upstream) signals over a TDM-PON has been demonstrated experimentally. Results indicate that incoherent multilevel formats are an attractive option for providing the high bit rates required for future TDM-PONs	
Tu.3.A.3 • 14:30 pg. 333 FPGA CONTROLLED INTEGRATED OPTICAL CROSS-CONNECT MODULE FOR HIGH PORT- DENSITY OPTICAL PACKET SWITCH Stefano Di Lucente ¹ , Jun Luo', Abhinaw Rohit', Shihuan Zou', Kevin A. Williams', Harm Dorren', Nicola Calabretta'; ' <i>IEE, TU/e, Netherlands.</i> We present a FPGA controlled 4x4 integrated WDM optical cross-connect followed by wavelength converters as optical module for building a large port optical backet	Tu.3.B.3 • 14:30 pg. 348 QUATERNARY TDM-PAM AND ITS IMPLICATIONS FOR TDMA EQUIPMENT Stefanos Dris', Johan Bauwelinck ² , Xin Yin ² , Bernhard Schrenk', Jose Lazaro', Vasilis Katopodis', Paraskevas Bakopoulos', Jozten Verbrugghe ² , Hercules Avramopoulos', Vasilina Technical University of Athens, Greece; ² INTEC:/IMEC - Ghent University, Belgium; ³ Universitat Politécnica de Catalunya, Spain. The migration towards a 20 Gb/s quaternary TDM-PAM	Tu.3.C.2 • 14:30 pg. 360 DIGITAL COHERENT SUPERPOSITION FOR PERFORMANCE IMPROVEMENT OF SPATIALLY MULTIPLEXED 676-GB/S OFDM-16QAM SUPERCHANNELS Xiang Liu ¹ , Sethumadhavan Chandrasekhar ¹ , Alan H. Gnauck ¹ , Peter Winzer ¹ , Sebastian Randel ¹ , Steve Corteselli ¹ , Benyuan Zhu ² , Thierry Taunay ² , Mikhail Fishteyn ² ; <i>Bell Labs, Alcatel-Lucent, USA</i> ; ² OFS Labs, USA.

optical cross-connect tollowed by wavelength converters as optical module for building a large port optical packet switch. Error free operation is obtained for 4 wavelength channels at 40 Gb/s NRZ with 4 dB penalty, switching time of 25 ns and energy consumption of 73,75 pJ/b.

14:00

14:15

14:30

The migration towards a 20 Gb/s quaternary TDM-PAM passive optical network with chirped and non-linear optical transmitters is experimentally studied. We show that a loss budget of 27.3 dB is compatible together with a packet power ratio of 10 dB between loud and soft ONU. USA. We demonstrate the use of digital coherent superposition to improve the performance of space-division-multiplexed (SDM) 676-Cb/s OFDM-16QAM superchannels, achieving -4 dB improvement in OSNR by using two SDM copies and 1075-km (14X76.8km) transmission over a seven-core-fiber with an effective aggregate spectral efficiency of 23.7 b/s/Hz.

ROOM D ROOM E ROOM F AUDITORIUM 14:00-15:30 14:00-15:30 14:00-15:30 14:00-15:00 Tu.3.D • Data Plane Solutions for Flexible and Elastic Optical Networks (SC5) Tu.3.E • Novel Materials & Methods (SC2) Tu.3.F • Active Few Mode Fibers (SC1) Tu.3.G • Tutorial Session II (SC6) Chair: Eduward Tangdiongga; Eindhoven Chair: Guang-Hua Duan; III-V Lab, France Chair: Hanne Ludvigsen; Aalto University, Finland University Technology, The Netherlands Chair: Jean-Pierre Hamaide; Alcatel-Lucent, France Tu.3.E.1 • 14:00 pg. 384 FIRST DEMONSTRATION OF IN-LINE PHASE

Tu.3.D.1 • 14:00 Invited pg. 369 INFRASTRUCTURE AND ARCHITECTURES ON DEMAND FOR FLEXIBLE AND ELASTIC OPTICAL

Dimitra Simeonidou¹, Norberto Amaya¹, Georgios Zervas1; 1 University of Essex, United Kingdom.

We propose Architecture on Demand (AoD) composition of optical nodes and networks in order to adapt to BW, switching and processing requirements of traffic. This facilitates flexibility and modularity in the optical layer and is key enabler for elastic optical networking.

Tu.3.D.2 • 14:30 pg. 372 PERFORMANCE EVALUATION OF ELASTIC OPTICAL NETWORKS WITH MULTI-FLOW OPTICAL TRANSPONDERS Takafumi Tanaka¹, Akira Hirano¹, Masahiko Jinno¹; ¹NTT

Network Innovation Laboratories, Japan

We compare elastic optical networks with multi-flow optical transponders (MF-OTPs) to networks with fixed-rate and adaptive-rate transponders in terms of spectrum efficiency (SE) and necessary number of transponders. Our evaluation shows that the elastic optical network with MFOTPs achieves high SE and low transponder

Takeshi Umeki¹, Hirokazu Takenouchi¹, Masaki Asobe¹; ¹NTT Photonics Laboratories, NTT Corporation, Japan. We demonstrate a x(2)-based in-line PSA with a carrier-

SENSITIVE AMPLIFIER BASED ON PPLN WAVEGUIDE

recovery and phase-locking system using wavelength conversion and injection locking.Phase regenerative amplification is achieved for 40 Gb/s DPSK signals with a wide phase sensitive dynamic range of 20 dB. The in-line PSA also operates successfully as a repeater amplifier in a 160 km fiber link

Tu.3.E.2 • 14:15 pg. 387 A NOVEL 3D STACKING METHOD FOR OPTO-ELECTRONIC DIES ON CMOS ICS ELECTRONIC DIES ON CMOS ICS Pinxiang Duan', Oded Raz', Barry Smalbrugge', Jercen Duis', Harm Dorren', 'Eindhoven University of Technology, Netherlands; ²TE connectivity, Netherlands.

High speed, high density and low cost solution for right speed, high teristy and two costs obtain for realizing optical interconnects is presented. An opto-electronic die, directly bonded on top of CMOS IC driver is connected using metal traces lithographically defined. A twelve channel transmitter based on the technique was

fabricated, and test shows good performance up to 12.5

Gb/s/ch

Tu.3.E.3 • 14:30 INVICE N/A CURRENT PATHWAYS TOWARDS SI-BASED LASERS Luca Dal Negro'; 'Department of Electrical and Computer Engineering, Boston University, USA. No abstract available.

Tu.3.F.1 • 14:00 pg. 397 IN-LINE FEW-MODE OPTICAL AMPLIFIER WITH ERBIUM PROFILE TUNED TO SUPPORT LP01, LP11, AND LP21 MODE GROUPS

AND LP21 MODE GROUPS Massimiliano Salsi', Jordi Vuong', Clemens Koebele', Philippe Genevaux', Haik Mardoyan', Patrice Tran', Sébastien Bigo', Guillaume Le Cocq', Laurent Bigo', Yves Quiquempois', Antoine Le Rouge', Pierre Sillard', Marianne Bigot-Astruc', Gabriel Charlet', 'Alcatel-Lucent Bell Jobe Emergia Tolegeme Suffance Bell Labs, France; 2 Telecom SudParis, France; 3 IRCICA, France; ⁴Prysmian Group, France.

We report and characterize an optical amplifier capable of five-mode amplification, with erbium concentration profile adjusted for low gain excursion across the modes. The cross-talk between modes is characterized in the middle of the C-band.

Tu.3.F.2 • 14:15 pg. 400 HIGH-ENERGY FOUR-WAVE MIXING, WITH LARGE-

HIGH-ENERGY FOUR-WAVE MIXING, WITH LARGE-MODE-AREA HIGHER-ORDER MODES IN OPTICAL FIBRES Lars S. Rishaj^{1,2}, Paul E. Steinvurzel¹, Yuhao Chen¹, Lu Yan¹, Jeffrey Demas¹, Michael Grogan¹, Tal Ellenbogen³, Ken Crozier³, Karsten Rottwitt², Siddharth Ramachandran¹, '*IECE - Photonics center, Boston* University, USA, ²DTU Fotonik, Denmark; ³Harvard University, USA.

We demonstrate, for the first time, four-wave mixing, in We demonstrate, for the maximum, not were many in the 1-µm spectral regime, in an LMA silica fiber. Pumping a 618-µm2 LP07 mode (λ_0 = 1038.4 nm) with a 1064.6 nm Nd:YAG laser results in the generation of modulation instability, and multiple Stokes/anti-Stokes lines, opening up the prospect of high-energy parametric processes with fibers

Tu.3.F.3 • 14:30 Invited pg. 403 OPTICAL VORTICES IN FIBRES: A NEW DEGREE OF FREEDOM FOR MODE MULTIPLEXING Siddharth Ramachandran', Nenad Bozinovic', Patrick Gregg', Steven Golowich', Poul Kristensen', 'Boston University, USA, 'MIT Lincoln Laboratory, USA,' OFS Fitel ApS, Denmark.

Optical vortices, which carry orbital angular momentum, form infinite-dimensional basis sets of orthogonal states, which make them attractive for modedivision multiplexing systems. We describe recent demonstrations of successfully generating & propagating vortices in optical fibres, and review recent transmission experiments conducted with them.

Tu.3.G.1 • 14:00 Tutorial pg. 412 NEXT GENERATION OPTICAL ACCESS TECHNOLOGIES

Peter Vetter1; 1Bell Labs, Alcatel-Lucent, USA.

This talk will provide an update of different next generation optical access technologies in a tutorial way. We will recap how the aggregate bandwidth of a PON can be further increased beyond the current standard Can be further increased beyond the during standard IOSbit/s capability by means of TDM-PON, hybrid TWDM-PON, WDM-PON, and OFDM-PON. We will compare how new concepts and technology research have made progress towards an easier deployment. lower cost, and lower energy consumption for each of the different alternatives

Peter Vetter is Department Head for Access Systems in Bell Labs Murray Hill. He received a PhD from Gent University in 1991 and worked as post-doc at Tohoku University, before joining the research centre of Alcatel (now Alcatel-Lucent) in Antwerp in 1993. In 2000, he became R&D lead for BPON in an Internal Venture that produced the first FTTH product in Alcatel. He also managed various European Research Projects, including the integrated project IST-MUSE. During his career, he has been interested in liquid crystal displays, optical interconnections, optical access, access platforms, access architectures, netcomputing for residentials, and energy efficient access.

	ROOM A	ROOM B
	14:00–15:30 Tu.3.A • Optical Switching (SC3)—Continued Chair: Ernesto Ciaramella; Scuola Superiore Sant'Anna, Italy	14:00–15:30 Tu.3.B • TDM PON II (SC6)—Continued Chair: Patrick lannone; AT&T, USA
14:45	Tu.3.A.4 • 14:45 pg. 336 DISTRIBUTED FAST OPTICAL PACKET POWER EQUALIZATION FOR EFFICIENT WDM PACKET SWITCHED NETWORKS Guilhem de Valicourt ¹ , Christian Simonneau ¹ , Francesco Vacondio ¹ , Laurence Lorcy ¹ , Jean-Christophe Antona ¹ , Sébastien Bigo ¹ , Dominique Chiaron ¹ , ¹ <i>Alcatel-Lucent</i> , <i>France.</i> We evaluate a distributed optical packet equalization scheme based on automatic gain control semiconductor optical amplifiers in a packet ring network. In presence of packet power discrepancies, we demonstrate that BER floors can be removed.	Tu.3.B.4 • 14:45 pg. 351 GPON SFP TRANSCEIVER WITH PIC BASED MODE- COUPLED RECEIVER Derek Nesset', David Piehler ² , Kristan Farrow ¹ , Neil Parkin ¹ ; ¹ BT, United Kingdom; ² NeoPhotonics, USA. The first mode-coupled receiver based SFP transceiver for GPON exploiting a photonic integrated circuit (PIC) has been developed and tested with a commercial GPON system. Measurements show the key performance advantages of reduced upstream split loss arising from utilising the MCR in a PON application.
15:00	Tu.3.A.5 • 15:00 IVIGO pg. 339 SILICON PHOTONICS BASED TRANSPONDER AGREGATOR FOR NEXT GENERATION ROADM SYSTEMS Tomoyuki Hino', Hitoshi Takeshita', Masahiro Sakauchi', Kiyo Ishiri', Junya Kurumida', Shu Namiki', Shigeki Takahashi', Shigeru Nakamura', Aklo Tajima'; 'Oreen Platform Research Labs, NEC corporation, Japan; 'Network Photonics Research Center, Advanced Industrial Science and Technology, Japan. After a brief review of the CDC-ROADM technologies for dynamic network systems, we demonstrate silicon photonics based transponder aggregators for 8-degree CDC-ROADM systems. Transponder aggregators in such systems play a key role in realization of the CDC function between multiple input/output fibers and multiple transponder	Tu.3.B.5 • 15:00 Invite gg. 354 FIELD-TRIAL OF 20 GB/S/A-BASED LONG-REACH NG-PON ON 100 KM LEGACY ODN V/A OPTICAL PON REPEATERS USING COHERENT SC-FDE DOWNLINK AND 10G-EPON BURST-MODE UPLINK Naoki Suzuki', Kenji Ishii', Masaki Noda', Satoshi Yoshima', Masamichi Nogami', Junichi Nakagawa'; ' <i>Mitsubishi Electric Corporation, Japan.</i> We demonstrate first field-trial of 100km long-reach NG- PON. With extended loss budget of 70.6dB, large access span loss of 30.6dB fully supporting legacy PON was bi-directionally achieved by using novel 20Gb/s coherent SC-FDE downlink and 10G-EPON burst-mode uplink via repeaters.

15:15

transponders.

15:30-16:00 Coffee Break, Hall 2

ROOM C

14:00–15:15 Tu.3.C • Spatial Multiplexing II (SC4)— Continued Chair: Polina Bayvel; University College London, UK 14:00-15:15

Tu.3.C.3 • 14:45 pg. 363 INVESTIGATING SELF-HOMODYNE COHERENT DETECTION IN A 19-CORE SPATIAL-DIVISION-MULTIPLEXED TRANSMISSION LINK Benjamin J. Puttnam', Jun Sakaguchi', Werner Klaus¹, Yoshinari Awaji', Jose Manuel Delgado Mendinueta¹, Naoya Wada¹, Atsushi Kanno², Tetsuya Kawanishi²; 'Photonic Systems Lab, NICT, Japan; ² Transmission Lab, NICT, Japan.

We investigate the performance of self-homodyne We investigate the performance of self-nonodyne coherent system based on 19°SDM and 16°WDM channels. We show that self-homodyne detection, with pilot-tone transmitted on 1 MCF core, is compatible with SDM transmission systems but inter-core crosstalk can limit potential advantages.

Tu.3.C.4 • 15:00 pg. 366 INFORMATION-THEORETIC SECURITY IN SPACE-DIVISION MULTIPLEXED FIBER OPTIC NETWORKS Kyle Guan', Peter Winzer', Emina Soljanin'; 'Bell Labs, Alcatel-Lucent, USA.

We study the use of space-division multiplexing to achieve information-theoretically provable physical-layer security against fiber tapping attacks in optical networks.

ROOM D

14:00-15:30 Tu.3.D • Data Plane Solutions for Flexible and Elastic Optical Networks (SC5)—Continued Chair: Jean-Pierre Hamaide; Alcatel-Lucent. France

Tu.3.D.3 • 14:45 pg. 375 DYNAMIC FLEXI-GRID OFDM OPTICAL NETWORKS Christina (Tanya) Politi¹, Vassilios Anagnostopulos¹, Chris Matrakidis¹, Alexandros Stavdas¹, ¹Department of Telecommunications Science and Technology, University of Peloponnese, Greece,

Dynamic flexi-grid optical networks are investigated with respect to the path establishment cost and spectrum and modulation format assignment policies. The role of spectral fragmentation with respect to the spectrum granularity and the benefit to distance adaptive OFDM flexi grid networks compared with rigid grid counterparts is established.

Tu.3.D.4 • 15:00 pg. 378 SPLIT SPECTRUM APPROACH TO ELASTIC OPTICAL NETWORKING

Stefan Dahlfort¹, Ming Xia¹, Roberto Proietti², S. J. Ben Yoo²; ¹Ericsson Research U.S.A., USA; ²Electrical and Computer Engineering, University of California, USA. This paper introduces the Split Spectrum approach to elastic optical networking and its figure of merit. Compared to elastic optical networking, Split Spectrum allows at least 50% more non-blocking traffic and 50% higher network spectral efficiency at non-blocking loads for the investigated scenarios.

Tu.3.D.5 • 15:15 pg. 381 FLEXIBLE AND ADAPTIVE OPTICAL METRO NETWORKING ON FIXED/FLEX GRID EXPLOITING HYBRID TIME/FREQUENCY FOR SHARED

RESOURCE ALLOCATION Bijan Rahimzadeh Rofoee', Georgios Zervas', Yan Yan', Norberto Amaya', Dimitra Simeonidou', 'University of Essex, United Kingdom.

A novel metro network architecture for co-existing Fixed-Grid and Flex-Grid networks is proposed. It delivers adaptive resource allocation in time and frequency dimensions for Fixed-Grid sub-wavelength, wavelength, waveband and Flex-Grid super-channel services over AoD optical nodes. Fixed and Flex Grid sharing spectrum show improved performance.

Vincent Stenger¹, James Toney¹, Jon Scholl¹, James Busch¹, Andrea Pollick¹, Peter Pontius¹, Sri Sriram¹; SRICO, Inc., USA.

Tu.3.E.4 • 15:00 pg. 391 WIDE-BAND ELECTRO-OPTIC MODULATOR IN THIN-FILM LITHIUM NIOBATE ON QUARTZ SUBSTRATE

ROOM E

Tu.3.E • Novel Materials & Methods (SC2)-

Chair: Guang-Hua Duan; III-V Lab, France

14:00-15:30

Continued

Tu.3.E.4 • 15:00

This paper reports the first demonstration of a high-speed electro-optic modulator in crystal ion sliced thin film lithium niobate (TFLN[™]). The device exhibits a Vrr.L of 4.75 V.cm, 8dB RF loss at 65 GHz and 40 GHz electro-optic bandwidth.

Tu.3.E.5 + 15:15 pg. 394 LOW-LOSS INTEGRATED 1×2 GRIDLESS WAVELENGTH SELECTIVE SWITCH WITH A SMALL NUMBER OF WAVEGUIDE CROSSINGS

Vuichiro Ikuma', Takayuki Mizuno², Hiroshi Takahashi², Tatsuhiko Ikeda', Hiroyuki Tsuda'; ¹Graduate School od Science and Technology, Keio University, Japan; ²NTT Photonics Laboratories, NTT Corporation, Japan.

A low-loss integrated 1×2 gridless wavelength selective switch (WSS) is reported. The WSS has a fewer waveguide crossings than a conventional device and only one multiplexer is needed. The bandwidth can be controlled from 200 GHz to 4000 GHz. The transmission loss and the crosstalk are less than 5.9 dB and -25.1 dB. respectively.

Tu.3.F.4 • 15:00 pg. 406 DESIGN AND CHARACTERIZATION OF A MULTIMODE EDFA SUPPORTING 4 TRANSVERSE MODE GROUPS FOR MODAL DIVISION

MULTIPLEXED TRANSMISSIONS Guillaume Le Cocq¹, Laurent Bigot¹, Antoine Le Rouge¹, Marianne Bigot-Astruc², Pierre Sillard², Yves Quiquempois¹; ¹PhLAM/IRCICA, France; ²Prysmian Group, France.

ROOM F

Chair: Hanne Ludvigsen; Aalto University, Finland

Tu.3.F • Active Few Mode Fibers (SC1)-

14:00-15:30

Continued

We report on a numerical and experimental study of a multimode EDFA suitable for mode division multiplexing. This EDFA is designed to equally amplify LP11 and LP21 modes with a gain close to 20 dB, which is confirmed by experimental and numerical results. This behavior is obtained by tailoring the erbium spatial distribution within the fiber core

Tu.3.F.5 • 15:15 pg. 409 EXPERIMENTAL INVESTIGATION OF INTER-MODAL CROSS-GAIN MODULATION AND TRANSIENT EFFECTS IN A TWO MODE GROUP ERBIUM DOPED

FIBER AMPLIFIER Yongmin Jung', Shaif-ul Alam', Zhihong Li', Peh Siong Teh', Anirban Dhar', Jayanta Sahu', Francesco Poletti', Richard Winfield^a, Andrew Ellis^a, David Richardson'; 10ptoelectronics Research Centre, University of Southampton, United Kingdom; ²Tyndall National Institute, University of College Cork, Ireland.

We report what we believe to be the first experimentally study of inter-modal cross-gain modulation and associated transient effects as different spatial modes and wavelength channels are added and dropped within a two-mode amplifier for SDM transmission.

15:30-16:00 Coffee Break, Hall 2

AUDITORIUM 14:00-15:00

Tu.3.G • Tutorial Session II (SC6)—Continued Chair: Eduward Tangdiongga; *Eindhoven University Technology, The Netherlands*

ROOM A

16:00-17:30 Tu.4.A • Optical Signal Generation (SC3) Chair: Oded Raz; Technical University of Eindhoven, Netherlands

Tu.4.A.1 + 16:00 pg. 454 GENERATION OF DPSK SIGNALS USING A DIRECTLY MODULATED PASSIVE FEEDBACK LASER Abdullah S. Karar', Ying Gao', Kang Ping Zhong', Jian Hong Ke', John C. Cartledge', 'Electrical and Computer Engineering, Queen's University at Kingston, Canada. 16:00

The generation of DPSK signals is demonstrated using a directly modulated passive feedback laser at 10.709, 14 and 16 Gb/s. The quality of the DPSK signals was assessed using both noncoherent detection (10.709 Gb/s) and coherent detection with digital signal processing involving a look-up table pattern-dependent distortion compensation scheme.

ROOM B

16:00-17:30 Tu.4.B • TDMA/WDM PON (SC6)

Chair: Albert Rafel; BT, UK

Tu.4.B.1 • 16:00 Invited pg. 472 XG-PON1 VERSUS NG-PON2: WHICH ONE WILL WIN? Frank Effenberger'; 'Access Adv. Tech. Dept., Futurewei Technologies, USA.

Performance, USA. By 2010, XG-PON technology had been standardized, but now NG-PON2 is following closely behind. The question of how these two systems will compete, coexist, or cooperate will be considered. NG-PON2 can be seen as an augmented version of XG-PON1, with a large amount of component reuse. So, it's not win or lose, but an ardedix succession an orderly succession.

ROOM C

16:00-17:15

Tu.4.C • OFDM (SC4) Chair: Helmut Griesser; ADVA AG Optical Networking, Germany

Tu.4.C.1 • 16:00 487

ILI.4.C.1*16:00 48/ ANALYSIS OF SPECTRALLY SHAPED DFTS-OFDM FOR FIBER NONLINEARITY MITIGATION Susmita Adhikari', Sander Jansen², Maxim Kuschnerov², Beril Inan³, Werner Rosenkranz¹; ¹Christian Albrechts University, Germany; ²Nokia Siemens Networks, Germany; ³Technical Univaersity of Munich, Germany. We investigate the benefit of implementing spectral shaping on DFTS-OFDM with respect to fiber nonlinearity tolerance. For both SSMF and LEAF, it is found that optimized spectrally shaped DFTS-OFDM outperforms

DFTS-OFDM for dispersion managed and unmanaged links by ~10.8% and ~6.8%, respectively.

16:15

Tu.4.A.2 • 16:15 pg. 457 A NOVEL TRANSMITTER FOR 320-GB/S PDM-RZ-16QAM GENERATION USING ELECTRICAL BINARY DRIVE SIGNALS Hyeon Y. Choi¹, Takehiro Tsuritani¹, Itsuro Morita¹; ¹KDDI R&D labs, Japan.

We propose a new transmitter for 16QAM generation based on a combination of a dual-drive Mach-Zehnder modulator (DD-MZM) and a dual-parallel Mach-Zeinhder modulator (DD-MZM) with electrical binary drive signals. By using the proposed transmitter, we successfully evaluated the performances of 224-Gb/s and 320-Gb/s PDM-RZ-16QAM signals.

Tu.4.C.2 • 16:15 pg. 490 EXPERIMENTAL DEMONSTRATION OF 28 GBAUD QPSK AND 16-QAM ZERO-GUARD-INTERVAL CO-OFDM TRANSMISSIONS Qunbi Zhuge', Mohamed H. Morsy-Osman', Mohammad Mousa-Pasandi', Xian Xu', Mathieu Chagnon', Ziad A. El-Sahn', Chen Chen', David V. Plant'; 'Dept. of Electrical and Computer Engineering, McGill University, Canada.

28 Gbaud QPSK and 16-QAM zero-guard-interval (ZGI) CO-OFDM transmission with only 1.34% overhead for OFDM processing is reported. The high tolerance of ZGI CO-OFDM to residual inter-symbol interference and imperfect frame synchronization is also demonstrated.

ROOM D ROOM E ROOM F AUDITORIUM 16:00-17:30 16:00-17:30 16:00-17:30 16:00-17:00 Tu.4.E • Integrated Devices (SC2) Chair: Yoshiaki Nakano; The University of Tokyo, Tu.4.F • Specialty Fibers (SC1) Chair: Patrice Megret; University of Mons/ Faculty Tu.4.D • Virtualization and Resilience (SC5) Tu.4.G • Tutorial Session III (SC3) Chair: Mario Pickavet; IBBT-Ghent University, Belgium Japan of Engineering, Belgium Portugal, Portugal

Tu.4.D.1 + 16:00 pg. 502 DYNAMIC VIRTUAL GMPLS-CONTROLLED WSON USING A RESOURCE BROKER WITH A VNT MANAGER ON THE ADRENALINE TESTBED Ricard Vilalta1, Raul Muñoz1, Ramon Casellas1, Ricardo Martínez1; 1CTTC, Spain.

We present a Resource Broker with a VNT Manager which dynamically deploys virtual GMPLS-controlled WSON networks. Virtual Optical links are constructed by grouping established lightpaths which are managed by the VNT Manager. We evaluate the performance of the Resource Broker in the ADRENALINE testhed highlighting the service deployment time

Tu.4.D.2 • 16:15 pg. 505 VIRTUAL OPTICAL NETWORK COMPOSITION OVER MIXED-LINE-RATE AND MULTIPLE-MODULATION-FORMAT WDM NETWORKS Shuping Peng¹, Reza Nejabati¹, Eduard Escalona¹

Dimitra Simeonidou^{1; 1}High Performance Networks Group, CSEE, University of Essex, United Kingdom. Taking into account the unique features of Mixed-Line-Rate and Multiple-Modulation-Format WDM networks, the cost-, resource-, and impairment-aware virtual optical network (VON) composition methods are proposed. which can create cost-effective and transmission qualityguaranteed VONs while achieving high network resource utilization efficiency.

Tu.4.E.1 • 16:00 pg. 520 DEMONSTRATION OF 12.5-GBPS OPTICAL INTERCONNECTS INTEGRATED WITH LASERS, OPTICAL SPLITTERS, OPTICAL MODULATORS AND PHOTODETECTORS ON A SINGLE SILICON

SUBSTRATE Yutaka Urino¹, Yoshiji Noguchi², Masataka Noguchi¹, Masahiko Imai¹, Masashi Yamagishi², Shigeru Saitou Naoki Hirayama², Masashi Takahashi², Hiroyuki Saitou² Takahashi¹, Emiko Saito¹, Takanori Shimizu¹, Makoto Okano², Nobuaki Hatori¹, Masashige Ishizaka¹, Tsuyoshi Okano², Nobuaki Hatori¹, Masashige Ishizaka¹, Tsuyoshi Yamamoto¹, Takeshi Baba¹, Takeshi Akagawa¹, Suguru Akiyama¹, Tatsuya Usuki¹, Daisuke Okamoto¹, Makoto Miura¹, Junichi Fujikata¹, Daisuke Shimura¹, Hideaki Okayama¹, Hinoki Yaegashi¹, Tai Tsuchizawa³, Koji Yamada¹, Masahiko Mori², Tsuyoshi Horikawa², Takahiro Nakamura¹, Yasuhiko Arakawa⁴; ¹Photonics Electronics Technology Research Association (PETRA), Japan; ²National Institute of Advanced Industrial Science and Technology (AIST), Japan; ¹NITT Microsystem Integration Laboratories, Japan; ¹Institute of Industrial Science, The University of Tokyo, Japan. University of Tokyo, Japan

Silicon optical interposers for inter-chip interconnects, integrated with an arrayed laser diode, an optical splitter, silicon optical modulators and germanium photodetectors on a single silicon substrate were demonstrated. A 12.5-Gbps error-free data transmission and 6.6-Tbps/cm2 transmission density were achieved.

Tu.4.E.2 • 16:15 pg. 523 10 GB/S INTEGRATED TUNABLE HYBRID III-V/SI LASER AND SILICON MACH-ZEHNDER MODULATOR G-H. Duan', C. Jany', A. Le Liepvre', J.-G. Provost', D. Make', F. Lelarge', M. Lamponi', F. Poingt', J.-M. Fedeli², S. Messaoudene³, D. Bordel², S. Brision², S. Keyvanina³, G. Roelkens³, D. Van Thourhout³, D. J. Thomson⁴, F. Y. Gardes⁴, G. T. Reedt', 'III-V Lab, a joint lab of 'Alcatel-Lucent Bell Labs France', 'Thales Research and Technology' and 'CEA Leti', France, 'CEA LETI, Minatec, France, 'Photonics Research Group, INTEC, Ghent Universiti-HBCC, Belgium', 'School of Electronics and University-IMEC, Belgium, ⁴School of Electronics and Computer Science, University of Southampton, UK.

We demonstrate a tunable transmitter, integrating a hybrid III-V/Si laser fabricated by wafer bonding and a silicon Mach-Zehnder modulator. The integrated transmitter exhibits 9 nm wavelength tunability by heating an intra-cavity ring resonator, high extinction ratio from 6 to 10 dB, and excellent bit-error-rate performance at 10 Gb/s.

Tu.4.F.1 • 16:00 pg. 535 BATCH MULTICORE AMPLIFICATION WITH

BATCH MULTICORE AMPLIFICATION WITH CLADDING-PUMPED MULTICORE EDF Yu Mimura', Yukihiro Tsuchida', Koichi Maeda', Ryo Miyabe', Keiichi Aiso', Hiroshi Matsuura', Ryuichi Sugizaki', *Furukawa Electic co.,Itd., Japan;* ²Tohoku Gakuin University, Japan.

We demonstrate multicore amplification with a double-cladding multicore erbium-doped fibre whose cladding is pumped by one multimode laser. We obtain gain of >15dB, noise figure of <5.5dB and crosstalk of <-30dB between 1580 and 1610nm. Two 10Ghit/s signals in each independent core are simultaneously amplified without additional penalty.

Tu.4.F.2 • 16:15 pg. 538 SIMULTANEOUS 7-CORE PUMPED AMPLIFICATION IN MULTICORE EDF THROUGH FIBRE BASED AN-IN/OUT

Yukihiro Tsuchida¹, Koichi Maeda¹, Kengo Watanabe¹ Tsunetoshi Saito', Shigeto Matsumoto', Keiigo Watanabe', Tsunetoshi Saito', Shigeto Matsumoto', Keiichi Aiso', Yu Mimura', Ryuichi Sugizaki'; '*Fitel Photonics Laboratory, Furukawa Electric Co., Ltd., Japan.*

We demonstrate multicore EDFA with simultaneous 7-core pump by utilizing small-diameter fibre bundle fanin/out. We confirm the characteristics with the gain > 15 dB, the noise figure < 7 dB, and the crosstalk < -40 dB in C-band. Seven 10 Gbit/s NRZ data are simultaneously amplified in each core with the power penalty within 0.5

Chair: Antonio Teixeira; Universidade de Aveiro

TU.4.G.1 • 16:00 TUTOTIAL pg. 550 GENERIC PHOTONIC INTEGRATION AS DRIVER FOR NEW SUBSYSTEM DEVELOPMENTS Meint Smit¹; ¹Technical University Eindhoven, Netherlands.

Photonic Integration has a great potential for manufacturing complex subsystems in a compact and cost-effective way. Entry costs for developing an integrated chip are high, however, which has restricted the application of Photonic ICs. Recent developments towards a generic foundry model in photonic integration lead to a dramatic cost reduction by using standardized high-performance integration processes in combination with a component library with a broad range of building blocks. It lead also to a reduction of the R&D time. The strongly reduced entry costs will bring Photonic ICs within reach for many SMEs in telecom and other applications.

Meint K. Smit graduated in Electrical Engineering in 1974 and received his Ph.D. in 1991, both with honours. He started research in Integrated Optics in 1981. He invented the Arrayed Waveguide Grating, for which he received a LEOS Technical Achievement award in 1997 received a LEOS technical Achievement award in 1997 and he was closely involved in the development of the MMI-coupler. Since 2000 he is the leader of the Photonic Integration group at the COBRA Research Institute of TU Eindhoven. His current research interests are in InP-based Photonic Integration, including integration of InP circuitry on Silicon. Meint Smit is a LEOS Fellow

16:00-17:30 16:00-17:30 Tu.4.B • TDMA/WDM PON (SC6)—Continued Tu.4.A • Optical Signal Generation (SC3)-Continued Chair: Albert Rafel; BT, UK Chair: Oded Raz; Technical University of Eindhoven, Netherlands Tu.4.A.3 • 16:30 pg. 460 GENERATION AND DETECTION OF 22.4-GBD 64QAM USING COHERENT OTD MUX AND ETD DEMUX APPROACH Tu.4.B.2 • 16:30 pg. 475 PERFORMANCE OF WAVELENGTH-SET DIVISION MULTIPLEXING PON-UPSTREAM IN THE O-BAND WITH OPTICAL PREAMPLIFICATION

Wolfgang Pöhlmann¹, Bernhard Depisch¹, Pietro Bernasconi², Thomas Pfeiffer¹; ¹Bell Labs, Germany; Wei-Ren Peng¹, Hyeon Y. Choi¹, Hidenori Takahashi¹, Itsuro Morita¹, Takehiro Tsuritani¹; ¹KDDI R&D Laboratories, Inc, Japan. ²Bell Labs, USA. WSDM is an attractive scheme to implement low cost PONs because of the simple, tunable upstream laser. The impact of the WS filter loss on the receiver sensitivity at the OLT side is investigated and found

With optical time-division-multiplexing and electronic time-division-demultiplexing (OMED), we experimentally demonstrate the generation and detection of 22.4-GBd/s (2xOTDM) 64QAM and investigate the system sensitivities against both the power imbalance and timing offset between tributaries.

ROOM A

Tu.4.A.4 • 16:45 pg. 463 DAC ENABLED SPECTRALLY EFFICIENT CP-QPSK AT 28GBAUD 16:45

16:30

Thomas Duthel¹, Christian Raabe¹, Peter Hermann¹, James E. Whiteaway¹, Jonas C. Geyer¹, Christopher R.S. Fludger¹, Theodor Kupfer¹; ¹Cisco Optical GmbH, Germany

We present channel spacing measurements on a 28Gbaud CP-QPSK transmitter applying Nyquist-like signal shaping without using optical filters. This is enabled by a single sample per symbol digital-to-analog converter in combination with strong analog electrical filtering. OSNR performance is evaluated against a commercial real-time receiver.

Tu.4.B.3 • 16:45 pg. 478 406BIT/S-CLASS-A-TUNABLE WDM/TDM-PON USING TUNABLE B-TX AND CYCLIC AWG ROUTER FOR FLEXIBLE PHOTONIC AGGREGATION NETWORKS

fulfills the basic requirements for NGPON2 and with SOA even an extended budget is supported.

ROOM B

Hirotaka Nakamura¹, Katsuhisa Taguchi¹, Shinya Tamaki, Takayuki Mizuno², Yasuaki Hashizume², Takashi Yamada², Mikitaka Itoh², Hiroshi Takahashi², Shunji Kimura¹, Naoto Yoshimoto¹; ¹NTT Access netrwork service systems labs., NTT, Japan; ²NTT Photonics Labs., NTT, Japan.

This paper proposes a 40bit/s-class- λ -tunable WDM/ TDM-PON for flexible photonic aggregation networks that achieves the aggregation of a large number of users using the DWBA without an L2-SW. A λ -switching transmission experiment was conducted using a newly developed λ -tunable B-Tx and 4 x 4 cyclic AWG router.

distance using EDFA only amplification to date.

16:00-17:15

Networking, Germany

Laboratories America, USA.

Tu.4.C.4 • 16:45 pg. 496 OPTIMIZATION OF JOINT 32/64-QAM SUBCARRIER MODULATION FOR 515-GBITS MULTI-BAND OFDM WDM TRANSMISSION WITH 50-GHZ CHANNEL SPACING THROUGH 320-KM SSMF TRANSMISSION Hidenori Takahashi¹, Wei-Ren Peng¹, Yu Kawaguchi¹, Takehiro Tsuritani¹, Itsuro Morita¹; ¹*KDDI R&D* Laboratories Inc., Japan.

ROOM C

Tu.4.C.3 • 16:30 pg. 493 PDM-OFDM-32QAM WDM SIGNALS TRANSMISSION

OVER 4,200 KM WITH NONLINEAR COMPENSATION AND EDFA ONLY AMPLIFICATION Ming-Fang Huang', Shaoliang Zhang', Eduardo Mateo', Fatih Yaman', Dayou Qian', Ting Wang'; 'NEC

Employing multi-band digital backpropagation for nonlinearity compensation, we experimentally demonstrated eight 100-Gbit/s PDM-OFDM-32QAM DWDM transmission over 4,242 km in a 12.5 GHz frequency grid. It achieves the longest transmission

Tu.4.C • OFDM (SC4)—Continued Chair: Helmut Griesser; ADVA AG Optical

Optimization of the joint 32/64-QAM subcarrier modulation is investigated using 3x515-Gbit/s multi-band OFDM transmission over 320-km SSMF with 50-GHz frequency grid. It is confirmed that the optimized joint 32/64-QAM with 20%-overhead FEC enables to increase OSNR sensitivity compared to 32-QAM with 7%-overhead FEC and 64-QAM with 20%-overhead FEC

ROOM D ROOM E ROOM F AUDITORIUM 16:00-17:30 16:00-17:30 16:00-17:30 16:00-17:00 Tu.4.E • Integrated Devices (SC2)—Continued Chair: Yoshiaki Nakano; The University of Tokyo, Tu.4.F • Specialty Fibers (SC1)—Continued Chair: Patrice Megret; University of Mons/ Faculty Tu.4.G • Tutorial Session III (SC3)—Continued Chair: Antonio Teixeira; Universidade de Aveiro Tu.4.D • Virtualization and Resilience (SC5)-Continued Chair: Mario Pickavet; IBBT-Ghent University, of Engineering, Belgium Japan Portugal, Portugal Belgium

Tu.4.D.3 • 16:30 pg. 508 EXPERIMENTAL EVALUATION OF A DYNAMIC PCE-BASED REGENERATOR-EFFICIENT IA-RWA ALGORITHM IN TRANSLUCENT WSON Alberto Castro', Ricardo Martínez', Luis Velasco', Ramon Casellas', Raul Muñoz', Jaume Comellas', 'Computer Architecture, Universital Politècnica de Catalunya (UPC), Spain', 'Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain.

We devise a novel dynamic PCE-based impairment-aware RWA algorithm in translucent GMPLS WSON that minimizes regenerator usage. Experimental evaluation carried out on the Open GMPLS/PCE control plane of CTTC ADRENALINE test-bed shows that significant improvements (>340%) are attained in terms of the offered traffic load.

Tu.4.D.4 • 16:45 pg. 511 SHARED MESH RESTORATION FOR OTN/WDM NETWORKS USING CDC-ROADMS Qiong Zhang', Xi Wang', Paparao Palacharla', Motoyoshi Sekiya', Daniel Bihon²; ¹Fujitsu Laboratories

of America, Inc., USA; ²Fuiitsu Network Communications. USA

We propose a coordinated shared mesh restoration scheme at sub-wavelength connection level using integrated OTN switch and CDC-ROADM nodes. The optical layer flexibility of CDC-ROADMs in the integrated simulation results show up to 18% savings in OTN line cards compared to classic ROADMs.

Tu.4.E.3 • 16:30 (Invited) pg. 526 DESIGN AND CHALLENGES IN A 100-GB/S HYBRID-INTEGRATED PHOTONIC CIRCUIT Pietro Bemasconi¹, Mark Earnshaw², Helene Debregeas³, Mohand Achouche³, Jeffrey H. Sinsky¹, Devid Mellenel Yoo Low² Dehard Earah² David

Deoregeas, Monana Achouche', Jerney H. Sinsky', David Neilson', Yee Low', Robert Farah', David Ramsey², Mahmoud Rasras², Nagesh Basavanahally², Flavio Pardo², Francois Brillouet', 'Bell Labs, Alcatel-Lucent, USA; 'Bell Labs, Alcatel-Lucent, USA; 'allI-V Lab, joint lab Bell Labs / Thales R&T, France. Hybrid-integrated, 10×10.7-Gbps WDM transmitters and

receivers are built upon DML arrays and APD arrays combined with electronic dispersion compensation. 80-km unamplified transmission is demonstrated with devices 32.5 cm2 in size and power dissipation under 17 W.

Tu.4.F.3 • 16:30 pg. 541 6 MW AND 30 MW LASER THRESHOLD FOR RESPECTIVELY 1ST AND 2ND BRILLOUIN STOKES ORDER IN A GE10AS24SE68 CHALCOGENIDE FIBER.

Kenny Hey Tow^{1,2}, Yohann Léguillon^{1,2}, Pascal Besnard^{1,2}, Laurent Brilland³, Johann Troles⁴, Perrine Toupin⁴, David Méchin³, Denis Trégoat³; ¹Université Européenne de Bretagne, Université de Rennes 1, France; ²CNRS UMR 6082 FOTON, France; ³PERFOS, R&D Platform of Photonics Bretagne, France; ⁴UMR 6226, Sciences Chimiques de Rennes, Equipe Verres et Céramiques, France.

A compact second-order Stokes Brillouin fiber laser made of microstructured chalcogenide glass is reported for the first time. This laser has very low optical pump-power threshold for Stokes conversion: 6 mW for first order and only 30 mW for second order with nonresonant pumping.

Tu.4.F.4 • 16:45) ((THULIUM-DOPED MODE-LOCKED ALL-FIBER LASER BASED ON NALM AND CARBON NANOTUBE SATURABLE ABSORBER

Maria Chernysheva¹, Alexander Krylov¹, Petr Kryukov¹, Natalia Arutunan², Anatoliy Pozharov², Elena Obraztsova², Evgeny Dianov¹; *Fiber Optics Research Center of Russian Academy of Science, Russian Federation; ²A.M. Prokhorov General Physics Institute of* the Russian Academy of Sciences, Russian Federation.

We report on a thulium-doped fiber laser mode-locked with a carboxymetylcellulose high-optical quality film with dispersed single-walled carbon nanotubes. Laser system based on the nonlinear amplifying loop mirror generates 450 fs pulses with 18 mW maximum average power.

ROOM A

Tu.4.A • Optical Signal Generation (SC3)-

Tu.4.A.5 • 17:00 pg. 466 OPTIMIZATION OF DSP-BASED NYQUIST-WDM PM-

Chair: Oded Raz; Technical University of Eindhoven, Netherlands

ROOM B

Tu.4.B • TDMA/WDM PON (SC6)—Continued

Tu.4.B.4 • 17:00 pg. 481 80-GB/S CONVENTIONAL HYBRID TDM/WDM

ROOM C

16:00-17:15

Tu.4.C • OFDM (SC4)—Continued Chair: Helmut Griesser; ADVA AG Optical Networking, Germany

Liang B. Du¹, Arthur Lowery¹; ¹Electrical and Computer Systems Engineering, Monash University, Australia.

80-GB/S CONVENTIONAL HYBRID TDM/WDM PON WITH 256-SPLIT BASED ON REMOTELY-PUMPED NETWORK-EMBEDDED SELF-TUNING TRANSMITTER Lucia Marazzi', Paola Palolari', Marco Brunero', Andrea Giussani', Romai Drenot', Sophie Barbet', Mario Martinelli', 'Dip. Elettronica e Informazione, Politecnico di Milano, Italy; 'Ill-V Lab, a joint lab of 'Alcatel-Lucent Bell Labs France', 'Thales Research and Technology' and 'CEA Leti', France. We present a conventional hybrid stacked-WDM/TDM-

16:00-17:30

Chair: Albert Rafel; BT, UK

We present a download in typing stacked which family PON system based on a colories network-embedded self-tuning transmitter assisted by a remotely pumped erbium-doped double-pass amplifier located at the remote node. The scheme provides up to 256-split PON with 80-Gb/s aggregate upstream capacity obtained with RSOA direct modulation at 2.5Gb/s.

Tu.4.B.5 • 17:15 pg. 484 FIELD TRIAL AND SIMULATION OF BANDWIDTH ALLOCATION FOR EFFICIENT OLT OPERATION ON VIRTUALIZED PON

Hiroyuki Saito', Hideyuki Iwamura', Naoki Minato', Shuko Kobayashi', Masahiro Sarashina', Hideaki Tamai', Kensuke Sasaki', Masayuki Kashima'; '*OKI electric* Industry, Japan.

First demonstration of the bandwidth allocation method for Virtualized PON was presented. To validate the principle of this method, we carried out field trial of 10Gbps-90km transmission using 10G-EPON system. We accomplished control of the user bandwidth.

OFIMICATION OF DSP-DASED NTGUISI-VUDW PM-16QAM TRANSMITTER Vittorio Curri¹, Andrea Carena¹, Gabriella Bosco¹, Pierluigi Pogolini¹, Fabrizio Forghier², ¹DET, Politecnico di Torino, Italy; ²Cisco Photonics Italy srl, Italy. Generation of PM-16QAM Nyquist-WDM signals in the

Generation of PM-190AM Nyquist-WDM signals in the digital domain is analyzed, by optimizing DSP and DAC parameters at different channel spacings. We show that ArcSin operation performed in DSP for compensating MZM non-linearity gives limited OSNR advantages and increases DSP complexity, but may give up to 3 dB gain in terms of launch power.

Tu.4.A.6 • 17:15 pg. 469 FLEXIBLE OPTICAL QAM GENERATION WITH A 17:15

16:00-17:30

Continued

17:00

FLEXIBLE OPTICAL QAM GENERATION WITH A LOW-COMPLEXITY AMPLIFIED INP SOA/EAM-BASED MODULATOR Bernhard Schrenk', Stefanos Dris¹, Paraskevas Bakopoulos', Ioannis Lazarou', Karsten Voigt², Lars Zimmermann³, Hercules Avramopoulos', 'School of Electrical & Computer Engineering, National Technical University of Athens, Greece; ¹Technische Universität Berlin, Germany, ³IHP GmbH, Germany.

Optical quadrature amplitude modulation (QAM) is experimentally demonstrated with a low-complexity, small form-factor and loss-less modulator based on a smicinductor optical amplifier and electro-absorption modulator. Flexible amplifier and electro-absorption up to 8-QAM is validated. Tu.4.C.5 • 17:00 pg. 499 EXPERIMENTAL INVESTIGATION OF THE EFFECT OF USING 'ODD AND EVEN' CHANNELS IN ALL-OPTICAL OFDM AND NYQUIST WDM SYSTEM COMPARISONS

We investigate experimentally the validity of using "odd and even" channels in all-optical OFDM and Nyquist WDM system demonstrations; odd and even channels provides insufficient decorrelation, which significantly affects the predicted performance.

ROOM D

ROOM E

16:00-17:30

16:00-17:30

Tu.4.D • Virtualization and Resilience (SC5)-Continued Chair: Mario Pickavet; IBBT-Ghent University,

Belgium

TU.4.D.5 • 17:00 pg. 514 SHARED PROTECTED ELASTIC OPTICAL PATH NETWORK DESIGN THAT APPLIES ITERATIVE RE-OPTIMIZATION BASED ON RESOURCE UTILIZATION EFFICIENCY MEASURES

EFFICIENCY MESURES Shun Kosaka', Hiroshi Hasegawa', Ken-ichi Sato', Takafumi Tanaka², Akira Hirano², Masahiko Jinno², 'Electrical Engineering and Computer Science, Nagoya University, Japan; ²NTT Network Innovation Laboratories, NTT Corporation, Japan.

We propose an advanced RSA algorithm that employs We propose an avoidated rSA algorithm tate inpluss iterative path relocation for shared protected elastic optical path networks. It enhances backup path sharing and reduces spectrum fragmentation. Numerical experiments verify that the proposed method ca substantially reduce the total number of fibers and frequency slots needed.

Tu.4.D.6 • 17:15 pg. 517 AN EFFICIENT WAVELENGTH PATH ASSIGNMENT METHOD FOR HYPERCUBE PHOTONIC NETWORKS Toshikazu Sakano¹, Shuto Yamamoto¹; ¹NTT Network Innovation Laboratories, Japan.

The lack of an efficient wavelength assignment method has made the operation of the hypercube photonic network, which is resilient against even severe disasters challenging. This paper proposes a novel method and reveals it achieves over 80% average accommodation efficiency.

Tu.4.E • Integrated Devices (SC2)—Continued Chair: Yoshiaki Nakano; The University of Tokyo, Japan

Tu.4.E.4 • 17:00 pg. 529 COMPACT SOI-BASED POLARIZATION DIVERSITY WAVELENGTH DE-MULTIPLEXER CIRCUIT USING TWO SYMMETRIC AWGS. Shibnath Pathak': Information Technology, Ghent University-imec, Belgium.

We demonstrate a compact 16-channel 200GHz Ver demonstrate compact routine metabolistic polarization diversity wavelength de-multiplexer circuit using two silicon AWGs and 2-D grating couplers. Insertion loss and crosstalk are 2.6dB and 21.5dB, respectively. The maximum polarization dependent wavelength shift is 0 115nm The total circuit size 1400X850µm2.

Tu.4.E.5 • 17:15 pg. 532 LOW-DRIVING-CURRENT INGAASP PHOTONIC-WIRE OPTICAL SWITCHES USING III-V CMOS PHOTONICS PLATFORM

Yuki Ikku¹, Masafumi Yokoyama¹, Osamu Ichikawa², Masahiko Hata², Mitsuru Takenaka¹, Shinichi Takagi¹; ¹Department of Electrical Engineering and Information Systems, The University of Tokyo, Japan; ²Sumitomo Chemical Company Ltd., Japan.

Electrically-driven Mach-Zehnder interferometer type InGaAsP photonic-wire optical switches using III-V CMOS photonics platform have been demonstrated. Optical switching with 10 dB extinction ratio was achieved with driving current of 200 $\mu A.$

ROOM F

16:00-17:30

Tu.4.F • Specialty Fibers (SC1)—Continued Chair: Patrice Megret; University of Mons/ Faculty of Engineering, Belgium

Tu.4.F.5 • 17:00 Invited

Tu.4.F.5 • 17:00 Invited pg. 547 PLASMONICS ON FIBERS COATED WITH METAL NANOPARTICLES Jacques Albert¹, Anatoli Ianoul¹, Sean Barry¹, Christophe Caucheteur², Li-Yang Shao³; ¹Carleton University, Canada; ²Université de Mons, Belgium; ³China Jiliang University, China.

University, China.

The cladding modes of standard optical fibers have well-defined polarization states and provide useful probes for plasmonic effects in nanoscale metal particles deposited on the fiber surface. Experimental results using high-Q resonances from tilted Fiber Bragg gratings will be presented.

	ROOM A	ROOM B	ROOM C
	09:00–10:30 We.1.A • Adaptable Subsystems (SC3) Chair: Antonio Teixeira; <i>IT, Portugal</i>	09:00–10:30 We.1.B • Reflective WDM-PON (SC6) Chair: Idelfonso Monroy; <i>Technical University of</i> <i>Denmark, Denmark</i>	09:00–10:30 We.1.C • Advanced Multilevel Modulation Formats (SC4) Chair: Yutaka Miyamoto; <i>NTT, Japan</i>
09:00	We.1.A.1 • 09:00 pg. 606 FULLY ADJUSTABLE SERIAL-PARALLEL FIR FILTER FOR COMPENSATION OF RESIDUAL CHROMATIC DISPERSION Stefan Schwarz', Abdul Rahim', Christian Schaeffer', Juergen Brunz', Klaus Petermann', 'High-Frequency Engineering and Optoelectronics, Helmut Schmidt University, Germany, 'High-Frequency Engineering, Berlin University of Technology, Germany.	We.1.B.1 + 09:00 pg. 621 OPTIMIZATION OF UNCOOLED RSOA PARAMETERS IN WDM REFLECTIVE PONS BASED ON SELF- COHERENT OR DIRECT DETECTION OLT RECEIVERS Giuseppe Rizzelli ¹ , Valter Ferrero ¹ , Stefano Straullu ² , Silvio Abrate ³ , Fabrizio Forghier ³ , Roberto Gaudino ¹ ; ¹ Politecnico di Torino, Italy; ² ISMB, Istituto Superiore Mario Boella, Italy; ² CISCO Photonics, Italy.	We.1.C.1 • 09:00 Invited pg. 639 NEW TRENDS AND CHALLENGES IN OPTICAL DIGITAL TRANMISSION SYSTEMS Colja Schubert', Johannes K. Fischer', Carsten Schmidt- Langhorst', Robert Elschner', Lutz Molle', Markus Nölle', Thomas Richter'; 'Photonic Networks and Systems, Fraunhofer Heinrich-Hertz-Institute, Germany. To satisfy the increasing capacity demand in today's enburgke, in particular generating the market of the set Networks and Systems and the set of
	For multi-channel compensation of residual chromatic dispersion we present a compact equalizer which can easily be realized in planar waveguide technology such as SOI. We show a two-stage architecture and analyze the improvement in controllability by adding one tunable coupler.	We investigate on the uncooled RSOA driving parameters in reflective-PONs, focusing on an upstream path at 1.25 Gbit/s and binary modulation. We show how the optimal values change using direct-detection or self-coherent receivers. We also address operating temperature dependence issues.	pose a severe challenge. This paper gives an overview of the concepts currently investigated to meet this challenge, including modulation formats, digital signal processing, elastic optical networks and multi-mode / multi-core transmission.
09:15	We.1.A.2 • 09:15 pg. 609 DUAL-STAGE FREQUENCY DOMAIN BLIND EQUALIZATION FOR LONG-HAUL COHERENT POLARIZATION-MULTIPLEXED QPSK AND 16-QAM SYSTEMS Chen Zhu', An V. Tran', Simin Chen', Liang B. Du ² , Trevor Anderson', Arthur Lowery', Efstratios Skafidas', 'Electrical and Electronic Engineering, NICTA, University of Melbourne, Australia; 'Electrical and Computer Science Engineering, Monash University, Australia. We present a dual-stage equalization method for long- haul coherent polarization-multiplexed systems. Blind CD compensation and adaptive multi-modulus equalization are both implemented in frequency-domain to allow zero	We.1.B.2 • 09:15 pg. 624 ENHANCED 10-GB/S OPERATION OF BANDWIDTH- LIMITED R-SOAS WITHOUT ELECTRONIC EQUALIZATION Marco Presi ¹ , Andrea Chiuchiarelli ¹ , Raffaele Corsini ¹ , Pallab Choudhury ¹ , Ernesto Ciaramella ¹ ; ¹ TeCIP, Scuola Superiore Sant'Anna University, Italy. By simply using a selected WDM demultiplexer, we obtain enhanced 10-Gb/s operation of a Reflective SOA having <1 GHz bandwidth by using simple direct detection. The scheme is robust to wavelength drifts up to 10 GHz. Error free operation is experimentally achieved over 20 km fibre, with no need for electronic equalization or FEC.	
09:30	overhead transmission with least complexity. Experiment is conducted to show good performance for both QPSK and 16-QAM systems. We.1.A.3 • 09:30	We.1.B.3 • 09:30 pg. 627	We.1.C.2 • 09:30 pg. 642
	PRINCIPLE OF ADAPTIVE-FILTER-BASED SIGNAL PROCESSING IN DIGITAL COHERENT RECEIVERS Kazuro Kikuchi'; 'University of Tokyo, Japan. Adaptive finite-impulse-response (FIR) filters in digital coherent receivers can achieve polarization demultiplexing, compensation for chromatic dispersion (CD) and polarization-mode dispersion (PMD), and	RECORD-HIGH ODN POWER BUDGET (MORE THAN 38 DB) IN SELF-COHERENT REFLECTIVE PON AT 1.25 GBIT/S AFTER PROPAGATION THROUGH 80 KM INSTALLED FIBERS Giuseppe Rizzelli', Valter Ferrero', Stefano Straullu ² , Silvio Abrate ² , Fabrizio Forghieri ² , Roberto Gaudino ¹ ; 'Politeonico di Torino, Italy: ² ISMB, Istituto Superiore Mario Revio, Intel ³ (ICO Denotorio, Italy: Companya Strauter, Italy: Mario Revio, Intel ³ (ICO Denotorio, Italy: Strauter, Italy: 1000 Denotorio, Italy	DESIGN RULES FOR PULSE SHAPING IN PDM- QPSK AND PDM-16QAM NYQUIST-WDM COHERENT OPTICAL TRANSMISSION SYSTEMS Jessica Fickers', Amirhossein Ghazisaeidi ⁷ , Massimiliano Salsi ² , Gabriel Charlet ⁹ , François Horlin ¹ , Philippe Emplit ¹ , Sébastien Bigo ² , ¹ OPERA, Université libre de Bruxelles, Belgium; ² Alcatel-Lucent Bell Labs, France.

(CD) and polarization-mode dispersion (PMD), and clock recovery all at once. This talk describes the physics behind such a variety of FIR-filter-based signal processing.

¹Poitecnico di Torno, Italy: ¹SMB, Istituto Superiore Mario Boella, Italy: ³CISCO Photonics, Italy. We experimentally demonstrate extremely high ODN optical power budget in self-coherent reflective PON at 1.25 Gbits' (upstream), allowing more than 38 dB attenuation in the ODN after propagation in 80 km installed fibers. This was obtained by optimizing R-SOA parameters at the ONU, (optional) Faraday rotation and DSP at the OLT.

Thanks to simulations, were discuss the choice of the optimal rolloff in realistic Nyquist-WDM systems, while accounting for transmitter/receiver impairments, namely the finite impulse response length of root-raised-cosine pulse shapes, jitter and vertical DAC/ADC resolution.

ROOM E

ROOM F

We.1.F • Fiber Process and Metrology (SC1) Chair: Benjamin Eggleton; University of Sydney,

We.1.F.1 • 09:00 Invited pg. 669 BRILLOUIN SUPPRESSED HIGHLY NONLINEAR

Lars Grüner-Nielsen¹, Dan Jakobsen¹, Søren Herstrøm¹,

Lais online relies , ban obsolute ; Josef and Santason ; Bera Palsköttir, Sonali Dasgupta; David Richardson?, Carl Lundström³, Samuel L. Olsson³, Peter A. Andrekson³; OFS Denmark, Denmark; ? Optoelectronic Research Centre, University of Southampton, United

Kingdom³Photonics Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology, Sweden.

Methods for suppression of stimulated Brillouin scattering in highly nonlinear fibers are reviewed. Emphasis is paid to SBS suppression by aluminum doping of the core. New results for a HNLF with an aluminum doped core

and reduced loss are presented.

ectronics

09:00-10:30

Australia

FIBERS

09:00-10:30

We.1.E • Transceivers (SC2) Chair: Liam Barry; Dublin City University, Ireland

We.1.E.1 • 09:00 pg. 654 ULTRACOMPACT, 160-GBIT/S TRANSMITTER OPTICAL SUBASSEMBLY BASED ON 40-GBIT/S×4 MONOLITHICALLY INTEGRATED LIGHT SOURCE

Takeshi Fujisawa¹, Shigeru Kanazawa¹, Kiyoto Takehata¹, Akira Ohki¹, Yuta Ueda¹, Ryuzo Iga¹, Hiroaki Sanjo¹, Takayuki Yamanaka¹, Masaki Kohtoku¹, Hiroyuki Sanjo¹, Takayuki Yamanaka¹, Masaki Kohto Ishii¹; ¹NTT Photonics Laboratories, Japan.

The first ultracompact transmitter optical subassembly for Inclusion of the second is demonstrated.

We.1.E.2 • 09:15 pg. 657 10 GBIT/S BIDIRECTIONAL MULTIMODE DATA LINK USING MONOLITHICALLY INTEGRATED VCSEL-PIN TRANSCEIVER DEVICES

Alexander Kern¹, Ahmed Al-Samaneh¹, Dietmar Wahl¹, Rainer Michalzik¹; ¹Institute of Optoelectronics, Ulm University, Germany.

The operation and optical crosstalk properties of lowcost AlGaAs-GaAs-based transceiver chips consisting of a VCSEL and a PIN photodetector are presented. Butt-coupled to a single 550 m long OM4-type standard multimode fiber, error-free bidirectional data transmission in full- and half-duplex mode is demonstrated at 10 Gbit/s.

We.1.E.3 • 09:30 pg. 660 200-68/S COMPACT CARD-EDGE OPTICAL TRANSCEIVER UTILIZING COST-EFFECTIVE FPC-BASED MODULE FOR OPTICAL INTERCONNECT

Takatoshi Yagisawa¹, Takashi Shiraishi¹, Yukito Tsunoda¹, Mariko Sugawara¹, Hideki Oku¹, Satoshi Ide¹, Tadashi Ikeuchi¹, Kazuhiro Tanaka¹; ¹Fujitsu Laboratories Ltd., Japan.

A compact card-edge optical transceiver with a cost-effective flexible printed circuit (FPC) based module structure has been developed. Clear eye-openings operating at 200 Gb/s (8-channel × 25 Gb/s) were successfully demonstrated. The optical power budget more than 4.5 dB was obtained even when the channel-to-channel cross-talk was included.

We.1.F.2 • 09:30 pg. 672 TENSION-OPTIMIZED HIGHLY NONLINEAR FIBER

FERSION-OF IMILED INSULT NONLINEAR FIGER FOR PARAMETRIC APPLICATIONS Carl Lundström¹, Evgeny Myslivets², Andreas O.J. Wiberg², Nicola Alic², Stojan Radic², Magnus Karlsson¹, Peter A. Andrekson¹; 'Photonics Lab., Dept. of Feler A. Anderson', Findines Lab, Dept. of Microtechnology and Nanoscience, Chalmers University of Technology, Sweden; ²Department of Electrical and Computer Engineering, University of California at San Diego, USA.

We investigate the Brillouin and dispersive properties including localized measurements of nonlinear fibers spooled with tension gradients and discuss their application in parametric devices.

09:00-10:30

AUDITORIUM

We.1.G Symposium on Energy Consumption of the Internet

Chairs: Tom Pearsall, European Photonics Industry Consortium (EPIC), France; Bart Lannoo, Ghent University - IBBT, Belgium; Mario Pickavet, Ghent University - IBBT, Belgium

SESSION 1: ELECTRICAL POWER GENERATION AND ENERGY-EFFICIENT NETWORK DESIGN Chair: Bart Lannoo, *Ghent University-IBBT, Belgium*

WELCOME AND INTRODUCTION

We.1.G.1 • 09:10 pg. 684 ESTIMATING THE GLOBAL POWER CONSUMPTION

IN COMMUNICATION NETWORKS Sofie Lambert, Ward Van Heddeghem, Willem Vereecken, Bart Lannoo, Didier Colle, Mario Pickavet; Ghent University - IBBT, Belgium

This presentation will estimate the worldwide power This presentation and carbon footprint of communication networks and compare this with other ICT fields such as data centres and personal computers. This paper concentrates on explaining the used methodology.

We.1.G.2 • 09:30 N/A THE ... 19.2 F US 30 N/A ELECTRICITY DEMAND AND SUPPLY PROJECTIONS IN IEA WORLD ENERGY SCENARIOS: HOW MUCH, HOW CLEAN?

Paolo Frankl: IEA. France

The presentation will highlight and discuss projections production for electricity demand up to 2050 based on the recent publication Energy Technology Perspectives 2012: Analysis of relevant generation mixes in different scenarios, Focus on scenario variants compatible with a long-term increase of average world temperature of 2°C, and in particular the Role of renewables in future clean electricity generation mixes.

ROOM A	ROOM B	ROOM C
09:00–10:30 We.1.A • Adaptable Subsystems (SC3)— Continued Chair: Antonio Teixeira; <i>IT, Portugal</i>	09:00–10:30 We.1.B • Reflective WDM-PON (SC6)— Continued Chair: Idelfonso Monroy; Technical University of Denmark, Denmark	09:00–10:30 We.1.C • Advanced Multilevel Modulation Format (SC4)—Continued Chair: Yutaka Miyamoto; <i>NTT, Japan</i>
	We.1.B.4 • 09:45 pg. 630 DWDM-PON AT 25 GHZ CHANNEL SPACING BASED ON ASE INJECTION SEEDING Joon-Young Kim', Sang-Rok Moon', Sang-Hwa Yoo', Chang-Hee Lee', ' <i>Electrical Engineering, KAIST,</i> <i>Republic of Korea.</i> We demonstrate a 25-GHz-channel-spaced DWDM-PON based on ASE injection seeding. A 60 km transmission of 1.25 Gb/s/ch is achievable with 2nd generation FEC. The major limiting factor is the reflective modulator gain.	We.1.C.3 • 09:45 pg. 645 DAC-FREE GENERATION AND 320-KM TRANSMISSION OF 11.2-GBD PDM-64QAM USING A SINGLE I/Q MODULATOR Wei-Ren Peng', Hidenori Takahashi', Takehiro Tsuritani', Itsuro Morita', ' <i>KDDI R&D Laboratories, Inc, Japan.</i> We successfully generate 11.2-GBd PDM-64QAM using one I/Q modulator driven with eight-level signals synthesized by all binary electrical inputs. The signal quality is verified with -1-dB Q marging (from 7% FEC threshold) after 320-km SSMF transmission.
We.1.A.4 • 10:00 pg. 615 EXPERIMENTAL DEMONSTRATION OF A FORMAT- FLEXIBLE SINGLE CARRIER COHERENT RECEIVER USING DATA-AIDED DIGITAL SIGNAL PROCESSING Robert Elschner ¹ , Felix Frey ¹ , Christian Meuer ^{2,1} , Johannes Karl Eischer ¹ , Saleem Altresh ^{2,1} Carsten	We.1.B.5 • 10:00 pg. 633 EXTENDED CANTY LIGHT SOURCE USING MODULATION-AVERAGING REFLECTORS FOR WDM-PON Tin Komljenovic', Dubravko Babic', Zvonimir Sipus'; 'Faculty of Electrical Engineering and Computing	We.1.C.4 • 10:00 pg. 648 EXPERIMENTAL INVESTIGATION OF 126-GB/S 6POLSK-OPSK SIGNALS Johannes K. Fischer ¹ , Saleem Alreesh ^{1,2} , Robert Elschner ¹ , Felix Frey ¹ , Christian Meuer ^{1,2} , Lutz Molle ¹ , Carsten Schmidt-L andporst ¹ . Takahito Tanimura ^{1,3} . Colia

10:00 We.1.A.4 - 10:00 pg. 615 EXPERIMENTAL DEMONSTRATION OF A FORMAT-FLEXIBLE SINGLE CARRIER COHERENT RECEIVER USING DATA-AIDED DIGITAL SIGNAL PROCESSING Robert Elschner¹, Felix Frey¹, Christian Meue⁻¹, Johannes Karl Flischer¹, Saleem Alreesh⁻¹, Carsten Schmidt-Langhorst¹, Lutz Molle¹, Takahito Tanimura³, Cojia Schubert¹, 'Irraunhofer HHI, Germany; ³Institut für Telekommunikationsysteme, Technische Universität Berlin, Germany; ³Fujitsu Laboratories, Japan. We experimentally demonstrate the use of data-aided digital signal processing for format-flexible coherent reception of different 28-GBd PDM and 4D modulated signals in WDM transmission experiments over up to 7680 km SSMF by using the same resource-efficient digital signal processing algorithms for the equalization of all formats.

10:15 We.1.A.5 • 10:15 pg.618 A NEW FAST AND BLIND CROSS-POLARIZATION MODULATION DIGITAL COMPENSATOR Paolo Serena¹, Amirhossein Ghazisaeidi², Alberto Bononi¹; ¹Ingegneria dell'Informazione, Universita degli Studi di Parma, Italy; ²Alcatel-Lucent, Bell Labs, France. We propose a novel blind feed-forward compensator of cross-polarization modulation for PDM-QPSK signals. Simulations show an improvement of 1 dB in Q-factor in a 112Gbit/s 2000km SMF dispersion-managed link.

10:30-11:00 Coffee Break, Hall 2

University of Zagreb, Croatia. Extended-cavity light sources employing modulationaveraging reflectors have been demonstrated for the time. We show that averaging reflectors add more that

Exercised and y init source comparing in motion of the first averaging reflectors have been demonstrated for the first time. We show that averaging reflectors add more than 3 dB to the link margin and allow a wider range of bias conditions for the RSOA. We also demonstrate 23 km transmission with a fully passive remote node at 1.25 GBaud.

We.1.B.6 • 10:15 pg. 636 UP TO 15KM CAVITY SELF SEEDED WDM-PON SYSTEM WITH 90KM MAXIMUM REACH AND UP TO 4.9GBIT/S CPRI LINKS

Asobin's Crinitine Fabiene Saliou', Philippe Chanclou', Benoit Charbonnier', Bertrand Le Guyader', Qian Deniel', Anna Pizzinat', Naveena Genay', Zhiguang Xu', Huafeng Lin²; 'Orange Labs, France: ²Huawei Technologies, China.

A WDM-PON system based on self-seeded RSOA is evaluated to provide long reach and high bit rate. For the first time, a maximum reach of 90km and a maximum bitrate of 4.9Gbit/s are achieved. Johannes K. Fischer¹, Saleem Alreesh^{1,2}, Robert Elschner¹, Felix Frey¹, Christian Meuer^{1,2}, Lutz Molle¹, Carsten Schmidt-Langhorst¹, Takahito Tanimura^{1,3}, Colja Schubert¹, ¹Photonic Networks and Systems, Fraunhofer Heinrich-Hertz-Institut, Germany; ²Technische Universitä Berlin, Germany; ³Fujitsu Laboratories, Ltd., Japan. We experimentally generate 28-GBd 6PoISK-QPSK

signals by utilizing a high-speed 4-channel DAC and an integrated dual-polarization I/Q modulator. In WDM transmission experiments over up to 4800 km standard single-mode fiber, we compare the performance of 126-Gb/s 6PoISK-QPSK and 112-Gb/s PDM-QPSK signals.

We.1.C.5 + 10:15 pg. 651 COMPARISON OF SET-PARTITIONED TWO-POLARIZATION 16QAM FORMATS WITH PDM-QPSK AND PDM-8QAM FOR OPTICAL TRANSMISSION SYSTEMS WITH ERROR-CORRECTION CODING Leremie Requirider! Adrian Vicinia! Origi Bertran-

Jeremie Renaudier', Adrian Voicila', Oriol Bertran-Pardo', Oliver Rival', Magnus Karlsson², Gabriel Charlet', Sebastien Bigo', 'Bell Labs, Alcatel-lucent, France; ²Chalmers University of Technology, Sweden.

We compare set partitioned two-polarization 16QAM formats with conventional PDM-QPSK and PDM-8QAM formats by considering error correction coding. We particularly show that 128SP-16QAM appear as a competitive alternative to PDM-8QAM for spectrally efficient (>4 b/s/Hz) optical transmission systems using forward error-correction coding.

09:45

ROOM E

ROOM F

09:00-10:30

We.1.E • Transceivers (SC2)—Continued Chair: Liam Barry; Dublin City University, Ireland

We.1.E.4 • 09:45 pg. 663 DEMONSTRATION OF ERROR-FREE 25GB/S DUOBINARY TRANSMISSION USING A COLOURLESS REFLECTIVE INTEGRATED

COLOURLESS REFLECTIVE INTEGRATED MODULATOR Caroline P. Lai', Alan Naughton', Peter Ossieur', Cleitus Antony', David Smith', Anna Borghesani', Dave Moodie', Graeme Maxwell', Peter Healey', Alistair Poustie', Paul Townsend', 'Photonic Systems Group, Tyndall National Institute, Ireland; 'CIP Technologies, United Kingdom.

We report on a hybrid reflective electroabsorption modulato-based photonic integrated circuit, demonstrating error-free 25.3Gb/s duobinary transmission (BER<1×10-12) over 35km of SSMF. Colourless operation with 1.2dB OSNR variation over the C-band is confirmed.

We.1.E.5 • 10:00 Invited pg. 666 SI PHOTONICS BASED HIGH-SPEED OPTICAL TRANSCEIVERS

Peter De Dobbelaere', Sherif Abdalla', Steffen Gloeckner', Michael Mack', Gianlorenzo Masini', Attila Mekis', Thierry Pinguet', Subal Sahni', Adithyaram Narasimha', Drew Guckenberger², Mark Harrison²; ¹Luxtera, USA; ²Molex, USA,

A Si Photonics technology platform has been developed for the manufacture of advanced optical transceivers. Integration methodologics, design, manufacturing, performance and roadmap of silicon photonics based transceiver ICs are addressed.

09:00-10:30 We.1.F • Fiber Process and Metrology (SC1)-Continued Chair: Benjamin Eggleton; University of Sydney, Australia

We.1.F.3 • 09:45 pg. 675 FABRICATION OF BRAGG GRATINGS IN MICROSTRUCTURED BI:SIO2 OPTICAL FIBER

MICROSTRUCTURED BI:SIO2 OPTICAL FIBER USING AN ARF LASER Georgios Violakis¹, Hans G. Limberger¹, Aleksander S. Zlenko², Sergey L. Semjonov², Valery M. Mashinsky², Evgeny Dianov², ¹STI, *EPIL, Switzerland*; *Fiber Optics Research Center RAS, Russian Federation.*

An ArF excimer laser was used to fabricate Bragg gratings in Bi:SiO2 core - microstructured cladding optical fiber. Average and modulated refractive index changes of 2.7_{-} 10-4 and $1.0 \times 10-4$ were induced in pristine fiber. Fiber luminescence was also measured under 1064 nm pumping.

We.1.F.4 • 10:00 pg. 678 INCREASING THE RESOLUTION OF OPTICAL SPECTROMETERS FOR THE MEASUREMENT OF

ADVANCED OPTICAL COMMUNICATION SIGNALS Stefan Preussler', Andrzej Wiatrek', Kambiz Jamshidi', Thomas Schneider'; ¹Institut fuer Hochfrequenztechnik, Hochschule fuer Telekommunikation Leipzig, Germany. High-resolution optical spectrum analysis is essential Inglin reconstant place operation and you to essential in the second optical, millimeter-wave and terahertz communication systems. A method for the measurement of power spectral density functions with a resolution of 5MHz is demonstrated.

AUDITORIUM

09:00-10:30 We.1.G Symposium on Energy Consumption of the Internet—Continued Chairs: Tom Pearsall. European Photonics

Industry Consortium (EPIC), France; Bart Lannoo, Ghent University - IBBT, Belgium; Mario Pickavet, Ghent University - IBBT, Belgium

We.1.G.3 • 09:50 pg. 687 ENERGY SAVING IN OPTICAL OPERATOR NETWORKS: THE CHALLENGES, THE TREND

NEIWORKS: THE CHALLENGES, THE TREND VISION, AND SOME RESULTS Filip Idzikowski', Raul Duque', Felipe Jim'enez', Esther Le Rouzic', Luca Chiaraviglior', Marco Ajmone Marsan'; 'Technische Universit at Berlin, Germany; 'Telefonica Investigacion y Desarrollo SA, Spain; 'Orange Labs, Networks and Carriers, France; 'DET Department, Politecnico di Torino, Italy

We discuss how to save energy in IP-over-WDM networks, presenting the vision of TREND, the FP7 NoE, and the saving that can be obtained with adaptive routing solutions that put network interfaces of various granularities to sleep in periods of low traffic. Results refer to two operator networks, considering power and traffic forecasts for 2020.

We.1.F.5 • 10:15 pg. 681 OPTIMIZATION OF DIFFERENTIAL LOCK-IN DETECTION FOR FIVE-FOLD ENHANCEMENT IN THE SPATIAL RESOLUTION OF A BOCDA SYSTEM

Jiho Jeong^{1,2}, Kwanii Lee⁷, Kwang-Yong Song³, Je-Myung Jeong², Sang-Bae Lee¹, 'Korea Institute of Science and Technology (KIST), Republic of Korea; ²Hanyang University, Republic of Korea; ³Chung-Ang University, Republic of Korea.

We propose and experimentally demonstrate the enhancement in the spatial resolution and the dynamic range of BOCDA by optimized differential lock-in detection. The spatial resolution is improved by more than five times compared to that of ordinary BOCDA.

We.1.G.4 • 10:10 pg. 690 ENERGY CONSUMPTION OF ICT INFRASTRUCTURES: AN OPERATOR'S VIEWPOINT Stéphane Gosselin¹, Fabienne Saliou¹, Fabrice Bourgart¹, Esther Le Rouzic¹, Stéphane Le Masson¹ and Azeddine Gati1; 1Orange Labs, France

The digital revolution has resulted up to now in the need for increasingly powerful and energy-hungry infrastructures. We give an operator's viewpoint on how to face this challenge, including some intermediate results of France Telecom Orange energy action plan and some expected technological and architectural evolutions of ICT infrastructures.

10:30-11:00 Coffee Break, Hall 2

	ROOM A	ROOM B	ROOM C
	11:00–12:30 We.2.A • Signal Processing and Detection (SC3) Chair: Werner Rosenkranz; <i>University of Kiel,</i> <i>Germany</i>	11:00–12:30 We.2.B • WDM-Access (SC6) Chair: Gabriella Cincotti; <i>University Roma Tre,</i> <i>Italy</i>	11:00–12:30 We.2.C • Nonlinear Interference (SC4) Chair: Rene-Jean Essiambre; Alcatel-Lucent, USA
11:00	We.2.A.1+11:00 [IVIED p. 693 ADVANCES IN SIGNAL PROCESSING Maxim Kuschnerov ¹ , Oscar Agazzi ² , Antonio Napoli ¹ , Stefano Calabrò ¹ , Vincent Sleiffer ² , Vladimir Veljanovski ¹ , Maximilian Hermann ¹ , Juraj Slovak ¹ , Christian Höfer ¹ , Ulrich Bauer ¹ , Thomas Rieger ¹ , Paul Vools ² , Norm Swenson ² , Marc Bohn ¹ ; ¹ Nokia Siemens Networks, <i>Germany</i> ² ClanPhy Communications, USA; ³ COBRA <i>institute</i> , <i>TU/e</i> , <i>Netherlands</i> . We review the latest developments and challenges in the field of digital signal processing for state of the art and future optical coherent communications for 400Gb/s and beyond.	We.2.B.1+11:00 pg.705 INTEGRATED 1.3/1.5 MM CYCLIC AWG ROUTER FOR A-TUNABLE WDM/TDM-PON Takayuki Mizuno', Yasuaki Hashizume', Takashi Yamada', Shinya Tamaki', Hirotaka Nakamura', Shunji Kimura', Mikitaka Itoh', Hiroshi Takahashi'; 'NTT Photonics Laboratories, NTT Corporation, Japan; 'NTT Access Network Service Systems Laboratories, NTT Corporation, Japan. We propose a cyclic NxN AWG router with which to realize a novel A-tunable WDM/TDM-PON with bandwidth allocation flexibility for inhomogeneous user distribution. We fabricated the router with silica-based PLC technology, and demonstrate that it can cyclically multi/demultiplex both 20 nm- and 200 GHz-spaced signals at 1.3 and 1.5 µm, respectively.	We.2.C.1+11:00 pg. 720 ON THE NONLINEAR CAPACITY WITH MEMORY OF PS-OPSK AND PDM-OPSK IN WDM NON- DISPERSION MANAGED LINKS Paolo Serena', Alberto Bononi', Giulio Colavolpe'; 'Ingegneria dell'Informazione, Universita degli Studi di Parma, Italy. We show a novel approach to numerically evaluate the information rate of long-memory nonlinear channels. We apply the technique to compare the spectral efficiency of PS-QPSK and PDM-QPSK in non-dispersion managed links.
11:15		We.2.B.2 • 11:15 pg. 708 SIMPLE INTRADYNE PSK SYSTEM FOR UDWDM-PON	We.2.C.2 • 11:15 pg. 723 INVESTIGATION OF THE DEPENDENCE OF NON- LINEAR INTERFERENCE ON THE NUMBER OF WOM

UWDM-PON Josep Prat, Victor Polo¹, Panagiotis Zakynthinos², Iván N. Cano¹, Jeison A. Tabares¹, Josep M. Fábrega³, Dimitrios Kiondids¹, Ioannis Tomkos², ¹Signal theory and communications, Universitat Politècnica de Catalunya (UPC), Spain, ²Athens Information Technology Center, Greece, ²Centre Tec. de Telecom. de Catalunya (CTTC), Spain.

An enhanced homodyne coherent system for ultra-dense WDM-PON is demonstrated, using conventional DFB, coupler instead of 90-deg hybrid and digital signal processing, achieving improved sensitivity and phase noise tolerance.

LINEAR INTERFERENCE ON THE NUMBER OF WDM CHANNELS IN COHERENT OPTICAL NETWORKS Rosanna Pastorelli¹, Gabriella Bosco², Andrea Carena², Pierluigi Poggiloin¹, Vittorio Curr², Stefano Piciaccia¹, Fabrizio Forghien¹, ¹ (Cisco Photonics Italy, Italy; ²Politecnico di Torino, Italy.

²Politecnico di Torino, Italy. We experimentally investigate nonlinearity impact in a multi-span uncompensated coherent optical system, transmitting, in the 50GHz grid, Nchx100G CP-DQPSK channels, varying Nch from 3 to 71. A good agreement was found with an analytical model, confirming the progressive growth of interference with Nch. Impacts on network design are evaluated.

ROOM D	ROOM E	ROOM F	AUDITORIUM
11:00–12:30 We.2.D • Physical Layer Aspects in Network Design (SC5) Chair: Naoya Wada; National Institute of Information and Communication Technology, Japan	11:00–12:30 We.2.E • Semiconductor Optical Amplifiers & All-Optical Techniques (SC2) Chair: Graeme Maxwell; <i>CIP Technologies, UK</i>	11:00–12:00 We.2.F • Nonlinear Dynamics & Applications (CLEO Focus) Chair: Pascal Kockaert; Université Libre de Bruxelles, Belgium	11:00–12:30 We.2.G Symposium on Energy Consumption of the Internet Chairs: Tom Pearsall, European Photonics Industry Consortium (EPIC), France; Bart Lannoo, Ghent University - IBBT, Belgium; Mario Pickavet, Ghent University - IBBT, Belgium
We.2.D.1+11:00 pg.738 WHAT IS THE BENEFIT OF WSS SPECTRAL GRANULARITY SMALLER THAN 50 GHZ FOR WDM NETWORKS EEATIBING ELASTIC SPECTRAL	We.2.E.1 • 11:00 pg. 753 MODULATION CANCELLATION PROPERTIES OF REFLECTIVE SOAS	We.2.F.1 • 11:00 InviteD pg. 771 NOVEL ULTRAFAST INTEGRATED SOURCES BASED ON NONLINEAR FREQUENCY CONVERSION	SESSION 2: ENERGY EFFICIENCY IN NETWORKS Chair: Tom Pearsall, EPIC - European Photonics Industry Consortium, France

GRANULARITY SMALLER THAN 50 GHZ FOR WE NETWORKS FEATURING ELASTIC SPECTRAL EFFICIENCY? Thierry Zami¹; ¹Alcatel-Lucent, France.

Assuming a core WDM elastic network carrying Nyquist superchannels, we quantify the corresponding extra total network capacity for various WSS spectrum granularities and various inter-superchannel guard bands.

We.2.D.2 • 11:15 pg. 741 A MULT-RING OPTICAL PACKET AND CIRCUIT INTEGRATED NETWORK WITH OPTICAL BUFFERING

Hideaki Furukawa¹, Satoshi Shinada¹, Takaya Miyazawa¹, Hiroaki Harai¹, Wataru Kawasaki², Tatsuhiko Satic², Koji Matsunga², Tatuya Toyozumi³, Naoya Wada¹; ¹National Institute of Information and Communications Technology, Japan; ²FUJITSU TELECOM NETWORKS LIMITED, Japan; ²Fujitsu Kyushu Network Technologies Limited, Japan.

We develop a multi-ring optical packet and circuit integrated network for the first time. Optical buffers are newly installed to a central 3×3 switch-node. 5-node hopping and 244 km transmission of 100 Gbps optical packets with 14 optical paths is achieved at a frame error rate <1E=4. Successful avoidance of packet collisions by buffers is shown. Sean O'Duill', Lucia Marazzi², Paola Palolari², Woltgang Freude¹, Christian Koos², Juerg Leuthodi²; ¹/Institute for Photonics and Quantum Electonics, Karlsruhe Institute of Technology, Germany; ²Dipartimento di Elettronica e Informazione, Politecnio Milano, Italy.

Modulation cancellation and signal inversion are demonstrated within reflective semiconductor optical amplifiers (RSOAs). The effect is useful to implement coloriess ONUs where downstream signals need to be erased in order to reuse the carrier for the upstream.

We.2.E.2 • 11:15 pg. 756 SIMULTANEOUS ALL PORT OPERATION OF 4-ARRAY SOA MODULE WITH WAVELENGTH-INSENSITIVE PARALLEL OPTICAL COUPLING SCHEME

Goji Nakagawa¹, Yutaka Kai¹, Kyosuke Sone², Setsuo Yoshida¹, Shinsuke Tanaka¹, Ken Morito¹, Susumu Kinoshita¹, '*Fujitsu Limited, Japan*, ²*Fujitsu Laboratories Limited, Japan*.

We have realized a wavelength-insensitive parallel optical lens coupling scheme and simultaneous driving of all 4 SOAs up to 300 mA in a 4-array integrated SOA module. We drastically improved loss variance over the wide wavelength range and thermal degradation in a module gain. We.2.F.1 + 11:00 <u>UNUES</u> pg. 771 NOVEL ULTRAFAST INTEGRATED SOURCES BASED ON NONLINEAR FREQUENCY CONVERSION Alessia Pasquazi', Marco Peccianti', Brent Little', Sai Chu', Dave Moss⁹, Roberto Moranddu'', IMRS-EMT, Canada: ²ISC-CNR UOS Montelibretti, Italy: ³Infinera Ltd, USA; ⁴Department of Physics and Materials Science, City University, Hong Kong; ⁸CUDOS, University of Sydney, Australia.

We summarize our recent results on the generation and of ultrafast optical signals in CMOS-compatible monolithic devices by exploiting the third order nonlinearity of glass based waveguides. We show that we can generate stable train of pulses at 200GHz rep rate with a novel passive mode-locking scheme based on an integrated ring resonator. We.2.G.1 • 11:00 N/A DRIVERS FOR GREEN NETWORK GEAR Peter Vetter; Bell Labs, Alcatel-Lucent, USA

This presentation will analyze drivers for a greener wireline network, including switching and routing, as well as optical transmission in the access and cores. Based on the research roadmap of GreenTouch, we will discuss research directions for more energy efficient network equipment from a vendor perspective.

We.2.G.2 • 11:20 pg. 780 ENERGY SAVING OPPORTUNITIES IN NEXT-GENERATION NETWORKS Biorn Skubic: Ericsson, Sweden

Network energy consumption involves aspects ranging from architecture and technology choices down to pure equipment design issues. Different opportunities for reducing power in next-generation networks will be discussed, including of fractific to the optical layer as well as adaptation of network power to traffic load.

ROOM A	ROOM B	ROOM C
11:00–12:30 We.2.A • Signal Processing and Detection (SC3)—Continued Chair: Werner Rosenkranz; University of Kiel, Germany	11:00–12:30 We.2.B • WDM-Access (SC6)—Continued Chair: Gabriella Cincotti; <i>University Roma Tre,</i> Italy	11:00–12:30 We.2.C • Nonlinear Interference (SC4)— Continued Chair: Rene-Jean Essiambre; Alcatel-Lucent, USA
We.2.A.2 • 11:30 pg. 696 16-QAM OPTICAL PACKET SWITCHING WITH REAL-TIME SELF-HOMODYNE DETECTION USING POLARIZATION-MULTIPLEXED PILOT-CARRIER Satoshi Shinada', Moriya Nakamura', Yukiyoshi Kamio', Naoya Wada', 'Naul Inst Info & Common Tech, Japan. We first demonstrated 20-Gbit/s 16-QAM optical packet switching and real-time detection. The modulated optical packets and pilot-carriers were simultaneously generated from a prototype pilot-carrier vector modulator and detected by simple self-homodyne receivers. Error-free operation was confirmed by a real-time error count using a packet BERT.	We.2.B.3 • 11:30 InviteD pg. 711 LOW COST TUNABLE RECEIVERS FOR WAVELENGTH AGILE PONS Robert Murano', Michael J. Cahill'; 'Aegis Lightwave, Inc., USA. Tunable receivers are a cost-effective means of increasing downstream bandwidth in legacy and next- generation colorless PONs, particularly those utilizing TWDM approaches. We review existing technologies and candidates for commercialization, and present guidelines for system design.	We.2.C.3 • 11:30 pg. 726 MODULATION FORMAT DEPENDENT PHASE NOISE CAUSED BY INTRA-CHANNEL NONLINEARITY Yangyang Fan', Liang Dou', Zhenning Tao', Lei Li', Shoichiro Oda ⁷ , Takeshi Hoshida ³ , Jens C. Rasmussen ³ , ¹ Fujitsu <i>R&D Center</i> , China; ² Fujitsu Laboratories Ltd., Japan; ³ Fujitsu Limited, Japan. The phase noise induced by the intra-channel nonlinearity with DP-16QAM is found to be higher than that with DP-0PSK in 1600km transmission experiments. The main reason is identified as the large IXPM in 16QAM based on the proposed nonlinear model.

11:45

11:30

We.2.A.3 • 11:45 pg. 699 IMPACT OF GAIN SATURATION ON THE PARAMETRIC AMPLIFICATION OF 16-QAM SIGNALS Francesco Da Ros¹, Robert Borkowski¹, Darko Zibar¹, Christophe Peucheret¹; ¹Department of Photonics Engineering, DTU Fotonik, Denmark.

The effect of gain saturation on parametric amplification of 16-QAM signals is investigated in terms of signal distortion. The relative impact of gain saturation, nonlinear phase rotation and nonlinear phase noise is discussed. Experimental results at 14 Gbd confirm the conclusions of the numerical analysis.

We.2.C.4 • 11:45 pg. 729 NONLINEAR THRESHOLD DECREASE WITH DISTANCE IN 112 GB/S PDM-QPSK COHERENT SYSTEMS Alberto Bononi', Nicola Rossi', Paolo Serena'; 'Ingegneria dell'Informazione, Università degli Studi di Parma, Italy.

We show that the accumulation rate of nonlinearity in NDM links can also be measured from the nonlinear threshold decrease rate, and provide simulations of such rates for each single- and cross-channel effect.

ROOM D	ROOM E	ROOM F	AUDITORIUM
11:00–12:30 We.2.D • Physical Layer Aspects in Network Design (SC5)—Continued Chair: Naoya Wada; National Institute of Information and Communication Technology, Japan	11:00–12:30 We.2.E • Semiconductor Optical Amplifiers & All-Optical Techniques (SC2)—Continued Chair: Graeme Maxwell; <i>CIP Technologies, UK</i>	11:00–12:00 We.2.F • Nonlinear Dynamics & Applications (SC7) Chair: Pascal Kockaert; Université Libre de Bruxelles, Belgium	11:00–12:30 We.2.G Symposium on Energy Consumption of the Internet—Continued Chairs: Tom Pearsall, European Photonics Industry Consortium (EPIC), France; Bart Lannoo, Ghent University - IBBT, Belgium; Mario Pickavet, Ghent University - IBBT, Belgium
We.2.D.3 • 11:30 pg. 744 EXPERIMENTAL DEMONSTRATION OF A COGNITIVE QUALITY OF TRANSMISSION ESTIMATOR FOR OPTICAL COMMUNICATION SYSTEMS Antonio Caballero ¹ , Juan Carlos Aguado ² , Robert Borkowski ¹ , Silvia Saldaña ¹ , Tamara Jiménez ² , Ignacio de Miguel ² , Valeria Arlunno ¹ , Ramón J. Durán ² , Darko Zibar ¹ , Jesper Bevensee Jensen ¹ , Rubén M. Lorenzo ² , Evaristo J. Abril ² , Idelfonso Tafur Monroy ¹ : ¹ OTU Fotonik, Technical University of Denmark, Denmark; ² University of Valladolid, Spain. We report on the experimental performance of a case- based reasoning technique to predict whether optical channels fulfill quality of transmission requirements, thus supporting impairment-aware networking, Validation is performed in a WDM 80 Gb/s PDM-QPSK testbed.	We.2.E.3 • 11:30 pg. 759 TWO-COPY WAVELENGTH CONVERSION OF AN 80 GBITS SERIAL DATA SIGNAL USING CROSS- PHASE MODULATION IN A SILICON NANOWIRE AND DETAILED PUMP-PROBE CHARACTERISATION Hua Ji', Ciaran S. Cleary ² , James M. Dailey ² , Ju Wang ^{3,1} , Hao Hu', Roderick P. Webb ² , Robert J. Manning ² , Michael Gallii, Palle Jeppesen', Minhao Pu', Kresten Yund', Leif K. Oxenlewe ¹ ; 'DTU Fotonik, Department of Photonics Engineering, Technical University of Demark, Denmark; ² Tyndall National Institute & Department of Physics, University College Cork, Ireland; 'School of Electrical and Information Engineering, Tianjin University, China. We experimentally demonstrate 80 Gbit/s wavelength conversion to two copies by simultaneously extracting the blue- and red-shifted sidebands from XPM in a silicon nanowire. Bit error rates of 10-9 with only ~2 dB power penalty is achieved for both sidebands. Detailed pump- probe characterisation reveals amplitude and phase responses.	We.2.F.2 • 11:30 pg.774 A NOVEL PHOTONICS APPROACH TO UNCONVENTIONAL INFORMATION PROCESSING Miguel C. Soriano', Daniel Brunner', Silvia Ortin', Claudio R. Miraso', Laurent Larger', Ingo Fischer', Luis Pesquera', 'IFISC (CSI-CJIB), Spain: 'IFCA (UNICAN- CSIC), Spain: 'FEMTO-ST (CNRS-UFC), France. We present a novel scheme in which photonic information processing can be performed using a photonic system with delayed feedback. Inspired by the way our brain process information, we show that a single optoelectronic oscillator with delay can replace a complex network of nonlinear dynamical elements without losing performance.	
We.2.D.4 • 11:45 pg. 747 ON THE INTEREST OF MULTI-BAND OFDM IN BACKHAUL NETWORKS Esther Le Rouzic ² , Nicolas Brochier ³ , Sofiene Blouza ² , Gwillerm Froc ¹ , Christophe Mangin ¹ , Michel Morvan ⁴ , Philippe Gravey ¹ , Jørkemie Jauffrif ⁴ , Michel Joindof ⁶ , Michiel van der Keur ³ , 'Systems Neworks and Services, Mitsubishi-Electric R&D Center Europe, France; ² Networks and Carriers, Orange Labs, France; ³ Ventworks and Carriers, Prinzee; ⁴ Ekinops, France; ⁶ Foton, Enssat laboratory, France; We present a novel all optical aggregation technology based on Multi-Band OFDM and evaluate its economical interest in a typical backhauin network configuration.	We.2.E.4+11:45 pg. 762 A DUAL PURPOSE, ALL OPTICAL MULTIPLEXER CIRCUIT IN INP: MUXING CLOCK AND DATA, AND TRANSMULTIPLEXING WDM TO TOM Piet Kuindersma', Xaveer Leijtens', Johan Van Zantvoort', Huug De Waardt'; ' <i>Electrical Engineering,</i> <i>COBRA, Netherlands.</i> We present a new, integrated all-optical multiplexer for A-grooming of many WDM channels into a single TDM channel. The chip was realized in a novel generic InP foundry process. Successful WDM to TDM transmultiplexing is demonstrated, as well as multiplexing of clock and NRZ data.	We.2.F.3 • 11:45 pg. 777 POLARIZATION ROGUE WAVES IN OPTICAL COMMUNICATION SYSTEMS Fabio Baronio ¹ , Antonio Degasperis ² , Matteo Conforti ¹ , Stefan Wabnitz ¹ , 'Dept. of Information Engineering, University of Broscia, Italy; ² Department of Physics, University of Rome I "La Sapienza", Italy. We obtain a novel family of rogue waves describing spatio-temporal localized extreme events for intensity and state of polarization of short of optical pulse trains in long-distance optical fiber communication links.	11:40 PANEL DISCUSSION

ROOM A	ROOM B	ROOM C
11:00–12:30 We.2.A • Signal Processing and Detection (SC3)—Continued Chair: Werner Rosenkranz; University of Kiel, Germany	11:00–12:30 We.2.B • WDM-Access (SC6)—Continued Chair: Gabriella Cincotti; University Roma Tre, Italy	11:00–12:30 We.2.C • Nonlinear Interference (SC4)— Continued Chair: Rene-Jean Essiambre; Alcatel-Lucent, USA
We.2.A.4 • 12:00 InviteD pg. 702 RECENT ADVANCES OF PARAMETRIC TUNABLE DISPERSION COMPENSATORS Ken Tanizawa', Junya Kurumida', Takayuki Kurosu', Shu Namiki', 'Network Photonics Research Center, National Institute of Advanced Industrial Science and Technology, Japan.	We.2.B.4 • 12:00 pg. 714 We.2.C.5 • 12:00 pg. 732 MITIGATION OF RAYLEIGH NOISE AND DISPERSION IN REAM-BASED WDM-PON USING PARTIAL- RESPONSE SIGNALING We.2.C.5 • 12:00 pg. 732 OI Guo', An Tran'; 'Victoria Research Laboratory, National ICT Australia, Australia. Muticipation of Non-Linear IM IN UNCOMPENSATED LINKS USI AMPLIFICATION We zec.so are used by the second of the	We.2.C.5 · 12:00 pg. 732 EVALUATION OF NON-LINEAR INTERFERENCE IN UNCOMPENSATED LINKS USING RAMAN AMPLIFICATION Vittorio Curril, Andrea Carena ¹ , Pierluigi Poggiolini ¹ , Gabriella Bosco ¹ , Fabricio Forgiheri ² , "DET, Politecnico di Torino, Italy; ² Cisco Photonics Italy srl, Italy.
We introduce parametric tunable dispersion compensator	backscattering and fiber dispersion in WDM-PON based	We extend a model for nonlinear propagation over

We introduce parametric tunable dispersion compensator based on FWM process in HNLF with low dispersion slope. Experimental demonstrations of the intrinsic advantages in operating bandwidth and tuning response and practical requirements such as polarizationinsensitive, colorless and in-line operations are reported.

> We.2.B.5 • 12:15 pg. 717 REFLECTIVE PACKET ADD-DROP MULTIPLEXER BASED ON MODULATION FORMAT AGNOSTIC AND LOW COST OPTICAL GATE

Low COST OF IICAL GATE Guilhem de Valicourt', Christian Simonneau', Francesco Vacondio', Dominique Chiaroni', Laurence Lorcy', Jean-Christophe Antona', Sébastien Bigo', Romain Brenof', Frederic Van Dijk', Harry Gariah'; 'Alcatel-Lucent, France; ²III-V Lab, France.

We propose a novel cost efficient node architecture for wavelength division multiplexed packet-switched network based on reflective devices. We demonstrate subwavelength switching and low energy consumption with a modulation format agnostic packet reflective optical switch. We extend a model for nonlinear propagation over lumped-amplified uncompensated links to setups using Raman amplification. We compare theoretical to simulative results for PM-16QAM Nyquist-WDM on PSCF links, showing an excellent agreement. We also show that Raman NLI enhancement gives limited practical impairments in realistic setups. We.2.C.6 • 12:15 pg. 735

We.2.C.6 + 12:15 pg. 735 EVALUATION OF THE DEPENDENCE ON SYSTEM PARAMETERS OF NON-LINEAR INTERFERENCE ACCUMULATION IN MULT-SPAN LINKS Andrea Carena¹, Pierluig Poggiolin¹, 'Vitorio Curri, Gabriella Bosco¹, Fabrizio Forghier¹, 'Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, Italy: 'Cisco Photonics Italy sri, Italy.

Non-linear effects in uncompensated links generate a noise-like additive interference: we study in detail the accumulation law vs. number of spans as a function of main system parameters (fiber types and VDM total bandwidth). In all practical cases, we analytically found a slightly super-linear accumulation confirmed by numerical simulations.

12:30–14:00 Lunch, on your own

12:00

12:15

ROOM D	ROOM E	ROOM F	AUDITORIUM
11:00–12:30 We.2.D • Physical Layer Aspects in Network Design (SC5)—Continued Chair: Naoya Wada; National Institute of Information and Communication Technology, Japan	11:00–12:30 We.2.E • Semiconductor Optical Amplifiers & All-Optical Techniques (SC2)—Continued Chair: Graeme Maxwell; <i>CIP Technologies, UK</i>		11:00–12:30 We.2.G Symposium on Energy Consumption of the Internet—Continued Chairs: Tom Pearsall, European Photonics Industry Consortium (EPIC), France; Bart Lannoo, Ghent University - IBBT, Belgium; Mario Pickavet, Ghent University - IBBT, Belgium
We.2.D.5 • 12:00 Invite pg. 750 APPLYING ORTHOGONALITY TO OPTICAL COMMUNICATIONS William Shieh'; ¹ The University of Melbourne, Australia. Identifying appropriate orthogonal function set to represent signals is one of the critical tasks in digital communications. In this paper, we focus on application of orthogonality in frequency and space domain for optical communications.	We.2.E.5 • 12:00 pg. 765 FAST ALL-OPTICAL 10 GB/S NRZ WAVELENGTH CONVERSION AND POWER LIMITING FUNCTION USING HYBRID INP ON SOI NANOCAVITY Kevin Lengle', Mathilde Gay', A. Bazin', I. Sagnes², R. Braive², P. Monnier', Laurent Bramerie', Nam Nguyen', Christelle Pareige', Robert Madec', Jean Claude Simon', Rama Raj², Fabrice Raineri?; 'CNRS FOTON UMR 6082, France; 'CNRS LPN UPR20, France.		

A new optical switch is presented using InP/SOI hybrid photonic crystal nanocavity. Switching contrast of 11 dB with 20 mVV peak power and recovery time of 14 ps are measured. NRZ wavelength conversion and power limiter are demonstrated at 10 Gb/s through system experiments with 6 and 1 mW peak power respectively.

We.2.E.6 • 12:15 pg. 768 ALL-OPTICAL WAVELENGTH CONVERSION OF 21.4-GB/S QPSK SIGNALS USING INTERSUBBAND TRANSITION IN INGAS/ALASSB COUPLED DOUBLE QUANTUM WELLS Ryoichi Akimoto', Haruhiko Kuwatsuka', Shin-ichiro Gozu', Teruo Mozume', Hiroshi Ishikawa'; 'Network Photonics Research Center, AIST, Japan.

Photonics Research Center, AIS1, Japan. We have demonstrated format-free wavelength conversion using cross-phase modulation associated with intersubband transition (ISBT) in a quantum wells waveguide. The waveguide functions as an all-optical phase modulator and a TM-polarized-QPSK launched signal that excites ISBT is converted to a cross-polarized TE-signal immune to ISBT absorption.

William Shieft, "The University of Melodurite, Australia. Identifying appropriate orthogonal function set to represent signals is one of the critical tasks in digital communications. In this paper, we focus on application of orthogonality in frequency and space domain for optical communications.

12:30-14:00 Lunch, on your own

	ROOM A	ROOM B	ROOM C
	14:00–15:30 We.3.A • Transmitters and Digital Coherent Receivers (SC3) Chair: John Cartledge; Queen's University at Kingston, Canada	14:00–15:30 We.3.B • Wireless and Free Space (SC6) Chair: Eduward Tangdiongga; <i>Eindhoven</i> University Technology, Netherlands	14:00–15:15 We.3.C • Interaction Non-linearities and Polarization (SC4) Chair: Alberto Bononi; <i>Parma University, Italy</i>
14:00	We.3.A.1 • 14:00 pg.783 EXPERIMENTAL TRANSMISSION WITH POLQAM AND PS-QPSK MODULATION FORMAT USING A 28-GBAUD 4-D TRANSMITTER Fred Buchali', Henning Buelow', 'Alcatel-Lucent, Germany. A transmitter with 4 digital-analog converters enabled the generation of 4-D optimized constellation with 6 polarization states (POLQAIM) at 28-6bd. A new feedback signal ensured adaptation of the CMA polarization demultiplexer in the off-line receiver and allowed comparison with polarization-switched QPSK (PS-QPSK) and DP-QPSK.	We.3.B.1+14:00 pg. 798 CONVERGED TRANSMISSION OF HIGH-CAPACITY DMT AND REAL-TIME DVB T BROACAST USING 50-M LONG 1-MM CORE SIZE PLASTIC OPTICAL FIBRE FOR IN-HOME NETWORKS Yan Shi', Marta Beltran', Chigo Okonkwo', Roberto Llorente Sáez', Eduward Tangdiongga', Ton Koonen'; 'COBRA Research Institute, Netherlands; 'Valencia Nanophotonics Technology Centre, Universidad Politécnica de Valencia, Spain. A low-cost in-home distribution of full-standard digital TV jointly with high bitrate data using large-core plastic optical fibre is proposed and demonstrated. A.2.7 Gb/s DMT signal and two-channel DVB-T video signals are generated, transmitted and received exhibiting excellent performance.	We.3.C.1 • 14:00 pg. 813 IMPROVEMENT OF TOLERANCE TO INTRA- CHANNEL NON-LINEAR EFFECT OF COHERENT HIGHER-ORDER MULTILEVEL SIGNALING WITH DIGITAL DELAY-DETECTION Nobuhiko Kikuchi', Shinya Sasaki', Tetsuya Uda'; 'Central Reseach Lab., Hitachi, Japan; ³ Telecommunication and Network Systems Division, Hitachi, Japan. We experimentally show the improvement of intra- channel non-linearity tolerance by 1.8 dB of coherent PM-160AM signal using digital-delay detection over highly-dispersed links, such as SSMF and long NZ-DSF links, and also improve it in low dispersion links by CD pre-distortion.
14:15	We.3.A.2 • 14:15 pg.786 ALL-ETDM 107-GBAUD (214-GB/S) SINGLE- POLARIZATION QPSK TRANSMITTER AND COHERENT RECEIVER Gregory Raybon', Andrew L. Adamiecki', Peter Winzer', Chongin Xie', Agnieszka Konczykowska', Filip Jorge ² , Jean-Yves Dupuy ² , Larry L. Buhl', Sethumadhavan Chandrasekhar', Steve Draving ³ , Marty Grove ³ , Kenneth Rush', Benyuan Zhu', David W. Peckham', 'Alcatel- Lucent, USA,' III/V Lab, Joint lab between Bell Labs, TRT and CEA/Leti, France; ³ Agilent Technologies, USA; '4OFS Labs, USA. We demonstrate an all-electronically multiplexed, single- polarization 107-Gbaud quadrature-phase-shift-keyed (QPSK) transmitter and coherent detection using a real-time oscilloscope prototype with 63-GHz electronic bandwidth, sampled at 160 GS/s. Using DFB lasers, we obtain back-to-back implementation penalty of 3 dB and 2400-km transmissio.	We.3.B.2 • 14:15 pg. 801 OPTICAL AND RADIO SEAMLESS MIMO TRANSMISSION WITH 20-GBAUD OPSK Atsushi Kanno ¹ , Toshiaki Kuri ¹ , Iwa Hosako ¹ , Tetsuya Kawanishi ¹ , Yoshihiro Yasumura ² , Yuki Yoshida ² , Ken- ichi Kitayama ² , 'National Institute of Information and Communications Technology, Japan; ² Graduate school of Engineering, Osaka University, Japan. MIMO radio transmission seamlessly converted from an optical DP-QPSK signal is performed with a polarization- diversity digital coherent detection technique. Obtained total capacity of radio transmission is achieved 74.4 Gb/s with 7% FEC overhead.	We.3.C.2 • 14:15 pg.816 PERFORMANCE ANALYSIS OF DECISION-AIDED NONLINEAR CROSS-POLARIZATION MITIGATION ALGORITHM Amintossein Chazisaeidi', Massimiliano Salsi', Jeremie Renaudier', Oriol Bertran-Pardo', Haik Mardoyan', Gabriel Charlet', 'Bell Labs, France. The performance of a decision-aided algorithm to mitigate the nonlinear cross-polarization in dispersion- managed polarization-multiplexed BPSK/QPSK systems is studied experimentally and numerically. Quality factor improvement depends on the ratio between the linear and nonlinear noise. The upper bound on the improvement is 0.9 dB.
14:30	We.3.A.3 • 14:30 (DVIEC) pg. 789 FLEXIBLE TRANSCEIVERS Kim Roberts', Charles Laperle', Michel Belanger'; ' <i>Ciena</i> <i>Corporation, Canada.</i> The introduction of coherent transceivers in high capacitly optical transmission systems has dramatically increased networking capabilities. We discuss how enhancing flexibility of these transceivers enables dynamic optimization of DWDM signal characteristics to extract more capacity from optical networks.	We.3.B.3 • 14:30 pg. 804 HIGH-SPEED INDOOR OPTICAL WIRELESS COMMUNICATION SYSTEM WITH A STEERING MIRROR BASED UP-LINK RECEIVER Ke Wang1 ² , Ampalavanapillai Nirmalattas ¹² , Christina Lim ² , Efstratios Skafdas ²¹ , Natoral ICT Australia- Victoria Research Laboratory (NICTA-VRL), Australia; ³ Department of Electrical and Electronic Engineering, The University of Melbourne, Australia. In this paper, we propose a steering mirror based up- link receiver for indoor optical wireless communication systems. Experimental results show that the up-link bit rate can be increased by >85% and the error-free (BER<10-9) beam footprint at 500Mbps can be improved by >39%.	We.3.C.3 • 14:30 pg. 819 MECHANISM AND QUANTITATIVE MODELING OF PMD-INDUCED REDUCTIONS OF XPM POLARIZATION CROSSTALK AND PHASE NOISE Yinwen Cao', Weizhen Yan', Zhenning Tao', Lei Li', Takeshi Hoshida', Jens C. Rasmussen', ¹ Fujitsu R&D Center (FRDC), China; ² Fujitsu Limited, Japan; ³ Fujitsu Laboratories Ltd., Japan. Numerical simulations show PMD reduces XPM polarization crosstalk more significantly than phase noise in dispersion-managed link. With novel explanation, quantitative XPM model is proposed to predict polarization crosstalk, phase noise, Q value for DP- QPSK and DP-16QAM systems with 0.1dB accuracy.

ROOM D	ROOM E	ROOM F	AUDITORIUM
14:00–15:30 We.3.D • Photonic Node Architectures and Technologies (SC5) Chair: Ken-ichi Sato; <i>University of Nagoya, Japan</i>	14:00–15:30 We.3.E • Complex Modulation Formats (SC2) Chair: Leo Spiekman; Alphion, USA	14:00–15:15 We.3.F • Semiconductor Lasers (CLEO Focus) Chair: Geert Morthier; <i>IMEC - Ghent University,</i> <i>Belgium</i>	14:00–15:00 We.3.G • Tutorial Session IV (SC1) Chair: Patrice Mégret; University of Mons, Belgium
We.3.D.1+14:00 pg. 828 A NOVEL LARGE-SCALE OXC ARCHITECTURE THAT EMPLOYS WAVELENGTH PATH SWITCHING AND EIPER SELECTION	We.3.E.1 • 14:00 pg. 846 DUAL-CARRIER DUAL-POLARIZATION IQ MODULATOR DRIVEN WITH HIGH-SPEED DACS FOR 400 CPIX APPL (CATUONS	We.3.F.1 • 14:00 INVICE pg. 864 INP BASED QUANTUM DOT/DASH MATERIAL FOR HIGH SPEED OPTOELECTRONIC DEVICES: RECENT	We.3.G.1 • 14:00 Tutorial pg. 876 FIBER FUSE - FROM A CURIOUS EFFECT TO A CRITICAL ISSUE

We.3.D.1 • 14:00 pg. 828 A NOVEL LARGE-SCALE OXC ARCHITECTURE THAT EMPLOYS WAVELENGTH PATH SWITCHING AND FIBER SELECTION Toshinori Ban¹, Hiroshi Hasegawa¹, Ken-ichi Sato¹,

Toshio Watanabe², Hiroshi Takahashi², ¹Department of Electrical Engineering and Computer Science, Nagoya University, Japan; ²NTT Photonics Laboratories, NTT Corporation, Japan.

We propose a novel large-scale OXC architecture that utilizes WSSs for dynamic wavelength grouping and 1xn switches for fiber selection. Our network design algorithm shows that the architecture attains significant hardware scale reduction. A prototype demonstrates good transmission performance and confirms the architecture's technical feasibility.

We.3.D.2 • 14:15 pg. 831 DYNAMIC AND FLEXIBLE PHOTONIC NODE ARCHITECTURE WITH SHARED UNIVERSAL TRANSCEIVERS SUPPORTING HITLESS

TRANSCEIVERS SUPPORTING HTLESS DEFRAGMENTATION Yasuhiko Aoki¹, Xi Wang², Paparao Palacharla², Kyosuke Sone³, Shoichiro Oda¹, Takeshi Hoshida¹, Motoyoshi Sekiya², Jens C. Rasmussen¹; ¹Fujitsu Ltd., Japan; ²Fujitsu laboratories of America, Inc., USA; ³Fujitsu laboratories, Ltd., Japan.

A dynamic and flexible network node architecture using modulation-flexible universal transceivers is proposed for beyond 100G transport. By sharing universal reduction of universal transceivers is realized under dynamic traffic condition.

We.3.D.3 • 14:30 pg. 834 LARGE-SCALE PHOTONIC NODE ARCHITECTURE THAT UTILIZES INTERCONNECTED SMALL SCALE OPTICAL CROSS-CONNECT SUB-SYSTEMS Yuto Iwai', Hiroshi Hasegawa', Ken-ichi Sato'; 'Department of Electrical Engineering and Computer Science, Nagoya University, Japan.

We propose a novel photonic node architecture that interconnects small-scale optical cross-connect systems Numerical evaluations verify that it offers almost the same performance as the equivalent single large-scale cross-connect switch, while enabling substantial hardware scale reductions.

We.3.E.1 • 14:00 pg. 846 DUAL-CARRIER DUAL-POLARIZATION IQ MODULATOR DRIVEN WITH HIGH-SPEED DACS FOR 400-GB/S APPLICATIONS

400-GB/S APPLICATIONS Hiroshi Yamazaki', Takashi Goh', Takashi Saida', Yasuaki Hashizume', Shinji Mino', Munehiko Nagatani¹, Hideyuki Nosaka', Koichi Murata'; '*NTT, Japan.* An optical dual-carrier generator, four parallel IQ modulators, and a polarization multiplexer are integrated in a single modulator with a silica-LiNbO S hybrid configuration. By driving the modulator with high-speed DACs we developed, we generated a 400-Gb/s dual-carrier dual-polarization 16QAM signal.

We.3.E.2 • 14:15 pg. 849 TEMPORAL MULTIPLEXING OF COMPLEX MODULATION FORMATS FACILITATED BY THEIR COHERENT OPTICAL SUPERPOSITION Francesca Parmigiani', Joseph Kakande', Liam M. Jones', Periklis Petropoulos', David Richardson'; ' Optoelectronics Resaerch Centre, United Kingdom.

We experimentally study passive coherent optical addition of complex modulation formats using delay line interferometers to increase their bits per symbol and, thus, their spectral efficiency. Two possible applications are demonstrated as examples.

We.3.E.3 • 14:30 pg. 852 GENERATION OF ARBITRARY COMPLEX OPTICAL DATA STREAMS USING A SINGLE AMPLITUDE-ONLY (MACH-ZEHNDER) MODULATOR

María R. Fernández-Ruiz¹, Ming Li¹, Jose Azana¹; ¹INRS - EMT, Canada. A new technique to significantly simplify the generation and detection of arbitrary complex-field

optical waveforms is presented, inspired by temporal counterparts of spatial-domain holography concepts. An 8-QAM signal is generated using a single Mach-Zehnder modulator and an optical band-pass filter.

Johann Peter Reithmaier¹, Gad Eisenstein²; ¹Institute of Nanostructure Technologies and Analytics, Universitaet Kassel, Germany; ²Electrical Engineering, Technion, Israel

RESULTS AND PROSPECTS

A review is given on the recent progress in 1.55 μm QD laser material based on an improved geometry control of QDs and its application in high speed optoelectronic devices. Also a prospect will be given for the realization of high speed directly modulated QD lasers having the potential to reach data rates of 25 GBit/s.

We.3.G.1 • 14:00 Tutorial pg. 876 FIBER FUSE - FROM A CURIOUS EFFECT TO A

CRITICAL ISSUE Raman Kashyap¹; ¹Ecole Polytechnique de Montreal, Canada.

Low power optical damage, which is accompanied by a Every point of plast admings, which is documpted by a beautiful and distinctive propagating plasma emission, was discovered by the author 25 years ago. This tutorial will trace the history and impact of the genie that escaped from its glass bottle.

Raman Kashyap has researched photonics for over 30 years, many at British Telecom Research Laboratories, Martlesham Heath, in United Kingdom. He currently holds the Tier 1 Canada Research Chair on Future Photonic Systems and has a joint Professorship in the Departments of Electrical Engineering and Engineering busics at Ecole Polytaching of Montreal. He is the Physics at École Polytechnique of Montreal. He is the Head of the Advanced Photonics Concepts Laboratory Head of the Advanced Photonics Concepts Laboratory and the \$4M laser micro-fabrication laboratory, "Fabulas". He has published over 350 articles and the first book on Fibre Bragg Gratings. He also discovered "Self-Propelled Self-Procusing" (SPSF), commonly known as the "fibre fuse", in 1987.

We.3.F.2 • 14:30 pg. 867 POLARIZATION BISTABLE VERTICAL CAVITY SURFACE EMITTING LASER (VCSEL): CONTROL AND MEMORY

AND MEMORY Mathias Marconi^{1,2}, Stéphane Barland¹, Massimo Giudici^{1,2}; ¹*Institut Non Linéaire de Nice, France*; ²*Université de Nice - Sophia Antipolis, France.*

We report on bistability in VCSEL involving two linear and orthogonal polarizations. The domain of coexistence is extended to the full current range of the device. We demonstrate control of the polarization state b perturbing optically the VCSEL. We show that the induced polarization state is recovered after having turned off and on the device

	ROOM A	ROOM B	ROOM C
	14:00–15:30 We.3.A • Transmitters and Digital Coherent Receivers (SC3)—Continued Chair: John Cartledge; Queen's University at Kingston, Canada	14:00–15:30 We.3.B • Wireless and Free Space (SC6)— Continued Chair: Eduward Tangdiongga; <i>Eindhoven</i> <i>University Technology, Netherlands</i>	14:00–15:15 We.3.C • Interaction Non-linearities and Polarization (SC4)—Continued Chair: Alberto Bononi; <i>Parma University, Italy</i>
14:45		We.3.B.4 • 14:45 pg. 807 1.25 GBIT/S VISIBLE LIGHT WDM LINK BASED ON DMT MODULATION OF A SINGLE RGB LED LUMINARY Christoph Kottke ¹ , Jonas Hilt ¹ , Kai Habel ¹ , Jelena Vučić ¹ , Klaus-Dieter Langer ¹ , 'Photonic Networks and Systems, Heinrich-Hertz-Institute, Germany.	We.3.C.4 • 14:45 pg. 822 STATISTICAL ANALYSIS OF THE INTERPLAY BETWEEN NONLINEAR AND PDL EFFECTS IN COHERENT POLARIZATION MULTIPLEXED SYSTEMS Olga Vassilieva', Inwoong Kim', Motoyoshi Sekiya'; 'Fujifsu Laboratories of America, Inc., USA.
		We report the first Gigabit-range visible light link based on off-the-shelf RGB-type white LEDs. By application of WDM and DMT modulation an aggregate rate of 1.25 Gbit/s within the FEC 2*10-3 limit has been reached at illumination levels recommended by the lighting standard for the working environment.	Statistical analysis of Q-factor distribution for combined NL and PDL effects reveals that interplay between NL and PDL effects changes the shape and width of the Q-distribution, depending on the dispersion map. A novel two-dimensional statistical method to visualize and analyze such transmission impairments is proposed.
15:00	We.3.A.4 • 15:00 pg. 792 LOW-COMPLEXITY DSP USING UNDERSAMPLING FOR HETERODYNE RECEIVERS IN COHERENT PASSIVE OPTICAL ACCESS NETWORKS Stefanos Dris', Paraskevas Bakopoulos', Ioannis Lazarou', Bernhard Schrenk', Hercules Avramopoulos'; 'National Technical University of Athens, Greece. The first application of bandpass sampling in a heterodyne coherent optical communication system	We.3.B.5 • 15:00 INVIGO pg. 810 ADVANCES IN VISIBLE LIGHT COMMUNICATION TECHNOLOGIES Shinichiro Haruyama'; 'The Graduate School of System Design and Management, Keio University, Japan. Visible light communication is a new way of wireless communication using visible light. We present new applications which will be made possible by visible light	We.3.C.5 • 15:00 pg. 825 PMD AND PDL TOLERANCES OF TRANSMITTER- SIDE NON-LINEAR MITIGATION IN 112 GB/S DP- OPSK TRANSMISSION Hisao Nakashima', Tomofumi Oyama', Yuichi Akiyama', Shoichiro Oda', Liang Dou', Yangyang Fan', Zhenning Tao', Takeshi Hoshida', Jens C. Rasmussen'; ' <i>Fujitsu</i> <i>limited, Japan; 'Fujitsu laboratories Ltd., Japan; 'Fujitsu</i> <i>R&D Center, China.</i>
	is presented. An undersampling receiver achieving a 50% reduction in ADC rate is developed in DSP and its penalty-free operation verified in a 76km coherent UDWDM-PON scenario.	communication echnology. Location-based services are considered to be especially suitable for visible light communication applications.	We experimentally demonstrate that the transmitter-side non-linear mitigation, combination of non-linear pre- distortion with RZ carving is robust against polarization mode dispersion and polarization dependent loss in real-time 112 Gb/s DP-QPSK transmission over 2,000km mixed fiber link.
15:15	We.3.A.5 • 15:15 pg. 795 FILTERLESS RECEPTION OF 80X112-GB/S WDM CHANNELS USING SINGLE-ENDED PHOTODIODES AND DIGITAL INTERFERENCE REDUCTION Yue-Kai Huang', Yin Shao', Ezra Ip', Philip N. Ji', Ting Wang', Yoshiaki Aono', Tsutomu Tajima'; 'NEC		

Ting Wang¹, Yoshiaki Aono², Tsutomu Tajima², '*NEC* Laboratories America, USA; ²Optical Network Division, NEC Corporation, Japan. A cost-effective filterless coherent receiving architecture is proposed using single-ended photodiodes. By dedicating two additional direct detection signal lanes to reject signal-signal interference in the digital domain, we successfully achieved the reception of 80x112-Gb/s WDM channels after 2000-km transmission with only 1.7-dB Q penalty.

15:30-16:00 Coffee Break, Hall 2

ROOM D ROOM E ROOM F AUDITORIUM 14:00-15:30 14:00-15:30 14:00-15:15 14:00-15:00 We.3.D • Photonic Node Architectures and Technologies (SC5)—Continued Chair: Ken-ichi Sato; *University of Nagoya, Japan* We.3.F • Semiconductor Lasers (CLEO Focus)—Continued Chair: Geert Morthier; *IMEC - Ghent University*, We.3.G • Tutorial Session IV (SC1)—Continued Chair: Patrice Mégret; University of Mons, We.3.E • Complex Modulation Formats (SC2)-Continued Chair: Leo Spiekman; Alphion, USA Belgium

We.3.D.4 • 14:45 pg. 837 RELIABLE FLEXIBLE-ROADM ARCHITECTURE ENABLING MODULATION FORMAT ADAPTATION Filippo Cugini¹, Francesco Paolucci², Nicola Sambo², Luca Poti1, Antonio D'Errico3, Giulio Bottari3; 1CNIT, Italy; 2Scuola Superiore Sant'Anna, Italy; 3Ericsson, Italy.

A ROADM architecture supporting flexible transponders is presented. Modulation format adaptation is effectively exploited to guarantee the full recovery of traffic tributaries while enabling the sharing of backup transponder modules.

We.3.D.5 • 15:00 pg. 840 OPTICAL LAYER-2 SWITCH NETWORK BASED ON WDM/TDM NANO-SEC WAVELENGTH SWITCHING Kyola Hatori, Masajaro Nakagawa', Naoki Kimishima' Masaru Katayama', Akira Misawa', Atsushi Hiramatsu'; ¹NTT Corporation, Japan.

It is necessary for metro networks to become more energy-saving/efficient for traffic from access networks. We propose Optical Layer-2 switch network, achieve dynamic bandwidth allocation and ADD/DROP with no buffer/header by changing wavelength in nsec according to allocated timeslots.

We.3.D.6 • 15:15 pg. 843 HIGH PERFORMANCE AND FLEXIBLE FPGA-BASED TIME SHARED OPTICAL NETWORK (TSON) METRO NODE

Yan Yan¹, Yixuan Qin¹, Georgios Zervas¹, Bijan Rahimzadeh Rofoee¹, Dimitra Simeonidou¹; ¹Computer Science and Electronic Engineering, University of Essex, United Kingdom.

The paper presents the architecture, implementation and evaluation of the flexible and finely granular Time Shared Optical Network metro node (TSON). The results show exceptional performance, throughput 95.38% of theoretical maximum, latency less than 160µsec and jitter less than 25µsec.

We.3.E.4 • 14:45 pg. 855 WHAT ELSE CAN AN AWG DO? Gabriella Cincotti¹; ¹Applied Electronics, University Roma Tre, Italy.

The large flexibility of the AWG configuration is demonstrated, showing that the device can be designed also to implement the discrete and fractional Fourier transforms. New configurations for QAM- and PSK-modulators are presented, as well as for polarization grating devices.

We.3.E.5 • 15:00 pg. 858 HIGHLY POLARIZATION MAINTAINING CIRCUIT-BASED DUAL PBS-INTEGRATED COHERENT MIXER WITH < 1 DEGREE POLARIZATION AXIS ROTATION Noritaka Matsubara', Takashi Inoue², Kazutaka Nara'; ICITE/ Observe to deverge Gordinee Constru-

Notitikal wildsubara, random mode, rucedant rado 17TEL Photonics Laboratory, Furukawa Electric Co., Ltd., Japan; ²Currently with National Institute of Advanced Industrial Science and Technology, Japan. We investigate a polarization sensitivity depending on waveguide circuit shapes in a silica-based PLC. Then we propose a highly polarization maintaining circuit with straight and S-shaped bending waveguides. A small polarization axis rotation < 1 degree was achieved in a fabricated dual PBS-integrated coherent mixer for coherent receivers.

We.3.E.6 • 15:15 pg. 861 CHARACTERIZATION OF LASER PHASE NOISE

USING PARALLEL LINEAR OPTICAL SAMPLING Tatsuya Okamoto¹, Masaaki Inoue¹, Fumihiko Ito¹; ¹NTT, Japan.

We propose a novel technique for characterizing laser The propose a transfer technique of that detailing due phase noise using parallel linear optical sampling. The high bandwidth of the linear optical sampling relaxes the bandwidth limitation, which is the critical problem in phase noise characterization using a digital coherent receiver.

Belaium

We.3.F.3 • 14:45 pg. 870 STABILITY OF A MONOLITHICALLY INTEGRATED FILTERED-FEEDBACK LASER Jng Zhao', Daan Lenstra', Rui Santos', Michael J. Wale', Meint Smit', Xaveer Leijtens'; 'Eindhoven University of Technology, Netherlands; ² Oclaro Inc., United Kingdom.

In this paper we experimentally investigate the stability of an integrated filtered-feedback laser as a function of the electrically controlled feedback phase. We interpret the measurements in terms of feedback-induced dynamics, by backing them up with the results of a stability analysis model.

We.3.F.4 • 15:00 pg. 873 ANTI-COLLIDING DESIGN FOR MONOLITHIC PASSIVELY MODE-LOCKED SEMICONDUCTOR LASERS

LASERS Julien Javaloyes¹, Salvador Balle^{1,2}; ¹*Fisica, Universitat de les illes balears, Spain*; ²*CMOOS, Instituto Mediterrani d'Estudis Avancats, Spain.*

The performance of two-section, passively mode-locked semiconductor lasers is theoretically analyzed for different cavity designs. Contrary to the intuition, placing a saturable absorber section close to an anti-reflection coated facet leads to a substantial increase in output power, reduces the jitter and broadens the region of table operation.

15:30-16:00 Coffee Break, Hall 2

16:00-17:30 Joint Poster Session

16:00-17:30

19:30-23:00 Conference Dinner on the "Saloon Steamer Prins van

Oranje"

P1.01 pg. 917 THZ GUIDANCE IN AIR CORE SQUARE-LATTICE PHOTONIC CRYSTAL FIBERS Jessienta Anthony', Rainer Leonhardt', Alexander Argross', "Physics Department, University of Auckland, New Zealand; ²School of Physics, University of Sydney,

SC1: Fibres, Fibre Devices, and Amplifiers

Australia. We present THz pulses propagation in square-lattice microstructured fibers with lattice constant of the same scale as the wavelengths.

P1.02 pg. 920 NEAR NYQUIST SINC OPTICAL PULSE GENERATION WTH FIBER OPTICAL PARAMETRIC AMPLIFICATION Armand Vedadi', Mohammad Amin Shoaie', Camille-Sophie Bres'; 'Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland.

Using optical fiber amplification and phase modulation, Using optical more amplitude and place modulation, we demonstrate experimentially the generation of pulses with characteristics that are close to Nyquist limited sinc pulses. Bandwidth limited pulses of full width half maximum less than 17 ps at 10 GHz repetition rate are achieved.

P1.03 pg. 923 FREQUENCY-DOMAIN ANALYSIS OF DYNAMICALLY APPLIED STRAIN USING SWEEP-FREE BRILLOUIN TIME-DOMAIN ANALYZER Asher Voskoboinik', Alan Willner', Moshe Tur's; '*Ming*

Astret Voskobornik', Alah Wilmer', Moste Tur', Wing Hsieh Department of Electrical Engineering, USC-Ean Sciences, USA; ²School of Electrical Engineering, Tel Aviv university, Israel. , arth

Fast reconstruction of the whole Brillouin gain spectrum Fast reconstruction of the whole binioun gain spectrum is experimentally demonstrated, using sweep-free Brillouin optical time-domain analysis (SF-BOTDA). Strain variations with frequencies up to 400Hz are spectrally analyzed, achieving strain sensitivity of 1 microstrain per root Hz at a sampling rate of 5.5KHz and a spatial resolution of 4m.

P1.04 pg. 926 EXPERIMENTAL STUDY ON IMPACT OF SOA NONLINEAR PHASE NOISE IN 40GBPS COHERENT 160AM TRANSMISSIONS Naohide Kamitani¹, Yuki Yoshida¹, Ken-ichi Kitavama¹

¹Osaka University, Japan.

The pattern effect in semiconductor optical amplifier (SOA) is experimentally investigated in 40Gbps coherent 16QAM transmissions. The pattern-dependent phase distortion reveals to strictly limit the operable range of SOA in ordinal coherent transceivers with linea

P1.05 P1.05 pg. 929 MODAL GAIN CONTROL IN A MULTIMODE ERBIUM DOPED FIBER AMPLIFIER INCORPORATING RING DOPING

DOPING Qiongyue Kang¹, Eeleong Lim¹, Yongmin Jung¹, Jayanta Sahu¹, Francesco Poletti¹, Shaif-ul Alam¹, David Richardson¹; ¹Optoelectronics Research Center, University of Southampton, United Kingdom.

We theoretically demonstrate the performance of a step index multimode (two mode-group) erbium-doped fiber amplifier with a localized erbium doped ring distribution for Space Division Multiplexed (SDM) transmission.

P1.06 pg. 932 DISTRIBUTED 32-BRANCHED PON MEASUREMENT USING PULSED PUMP-PROBE BRILLOUIN

ANALYSIS

Hiroshi Takahashi', Xinyu Fan', Yusuke Koshikiya', Fumihiko Ito'; ¹NTT Access Network Service System Laboratories, Japan. We describe the individual loss distribution measurement

of 32-branched PONs using pulsed pump-probe Brillouin gain analysis. We describe the measurement of 32-branched optical fibers with a fault location resolution of 10-m and a branch length identification resolution of 5-m.

P1.07 pg. 935 SUPERCONTINUUM GENERATION IN PICOSECOND REGIME IN A HIGHLY NONLINEAR TAPERED TELLURITE MICROSTRUCTURED OPTICAL FIBER Meisong Liao¹, Weiqing Gao¹, Tonglei Cheng¹, Zhongchao Duan¹, Takenobu Suzuki¹, Yasutake Ohishi¹;

¹TTI, Japan.

We have demonstrated broad SC generation from UV to mid IR by using a highly nonlinear tapered tellurite microstructured fiber pumped by a 15-ps-pulsed laser with the peak power of 375 W. The constructed SC light source is cost-effective, since neither femtosecond pulsed laser nor high power picosecond pulsed laser is adopted.

P1.08 pg. 938 MULTI-CORE FEW-MODE OPTICAL FIBERS WITH LARGE AEFF Kazunori Mukasa¹, Katsunori Imamura¹, Ryuichi Sugizaki¹; ¹Furukawa Electric Co., Ltd., Japan.

We designed and fabricated 7-core and 19-core few-mode fibers with large Aeff of 170µm2 (LP01 mode). We discuss the potentials and required challenges of realizing large-Aeff multi-core few-mode fibers taking intra-core and inter-core cross-talk into account.

P1.09 pg. 941 PRACTICALLY DEPLOYABLE AND EFFECTIVELY SINGLE-MODE ALL-SOLID PHOTONIC BANDGAP FIBRE WITH AN EFFECTIVE AREA OF 1028 MM2 Masahiro Kashiwagi', Kunimasa Saitoh', Tomoya Ichige', Katsuhiro Takenaga', Shoiji Tanigawa', Shoichiro Vatarial Munches Enimasha Silut Id. Japag

Matsuo¹, Munehisa Fujimaki¹; ¹Fujikura Ltd., Japan; ²Hokkaido University, Japan.

Effective area limit for a practically deployable and effectively single-mode all-solid photonic bandgap fibre is investigated. 1028-µm2 effective area and 0.09 dB/m bending loss at 20-cm bending radius are achieved in a fabricated fibre.

P1.10 pg. 944 COHERENCE CHARACTERIZATION OF KHZ-LINEWIDTH LASER BY FIBRE SPECKLE ANALYSIS

Masaaki Inoue', Fumihiko Ito', Xinyu Fan', Yusuke Koshikiya'; '*NTT Access Network Service Systems* Laboratories, Japan.

Modulus of the degree of coherence (DOC) of a kHzlinewidth laser is fully characterized for the first time by using a single test laser. The phase-error variance for a short delay is analysed, which is important in coherent communication.

P1.11 pg. 947 OPTICAL NONLINEARITY IN MULTI-MODE FIBERS

WITH RANDOM MODE COUPLING Antonio Mecozzi¹, Cristian Antonelli¹, Mark Shtaif²; ¹Electrical and Information Engineering, University of L'Aquila, Italy, ²School of Electrical Engineering, Tel Aviv University, Israel.

We derive the fundamental equations describing nonlinear propagation in multi-mode fibers in the presence of random mode coupling within quasi degenerate groups of modes. Our result generalizes the Manakov equation describing mode coupling between polarizations in single-mode fibers.

SC2: Waveguide and Optoelectronic Devices

P2.01 pg. 950 LONGITUDINAL HOLOGRAMS FOR DIGITAL FREQUENCY SELECTION AND ELECTRONIC TUNING IN TERAHERTZ QUANTUM CASCADE

Subhasish Chakraborty¹, Owen Marshall¹, Md Khairuzzaman1, Harvey Beere2, David Ritchie2; 1School of Electrical and Electronic Engineering, The University of Manchester, United Kingdom; ²Physics, University of Cambridge, United Kingdom.

Terahertz (THz) quantum cascade lasers (QCL) operating round 2.9 THz are modified with longitudinal computer generated hologram (LCGH) structures <3 mm in total length to achieve purely electronic discrete funing on six modes spanning over 160 GHz. The behavior and digital frequency selection offered by LCGH QCLs is shown to be reproducible.

P2.02 pg. 953 AMPLITUDE REGENERATION OF PHASE CODED SIGNALS Claudie De Control Claudio Porzi¹, Antonella Bogoni², Giampiero

Contestabile1: 1TeCIP, Scuola Superiore Sant'Anna, Italy: ²CNIT - National Laboratory of Photonic Networks, Italy

We show that a saturated semiconductor optical amplifier reduces the amplitude noise of phase-coded signals without adding excess phase noise in presence of an additional CW beam with proper power. Passthrough and four-wave-mixing copyrights. I define through and four-wave-mixing converted signals exhibit significant improvement of the BER threshold margin for 10 Gb/s NRZ DPSK data.

P2.03 pg. 956 COMPACT INP-ON-SOI MICRODISKS USED AS HIGH-

SPEED MODULATORS AND PHOTO DETECTORS Jens Hofrichter¹, Thomas Mor¹, Antonio La Porta¹, Oded Raz², Harm Dorren², Bert J. Offrein¹; ¹IBM Research - Zurich, Switzerland; ²Eindhoven University of Technology, Netherlands.

We demonstrate for the first time that a single compact electrically contacted indium phosphide based microdisk heterogeneously integrated on a silicon-on-insulator waveguide can be used as both a high-speed modulator and photo detector. We demonstrate high-speed operation up to 10 Gb/s and present bit-error rate results of both operation modes.

P2.04 pg. 959 AMPLITUDE AND PHASE DYNAMICS OF

Concatenated solution of the s Cork, Ireland.

Measurements of amplitude and phase dynamics of a concatenated SOA-EAM-SOA show 1/e amplitude recovery times as short as 2.6ps under optimal conditions, with longer 1/e phase recovery times (\geq 38ps). Due to the extremely fast amplitude recovery, the impulse response consists predominantly of a phase component only.

P2.05 pg. 962 NOVEL PHOTONIC INTEGRATION PLATFORM

BASED ON ELECTRO-OPTIC POLYMERS Panos Groumas¹², Ziyang Zhang², David de Felipe², Vasilis Katopodis¹, Christos Kouloumentas¹, Raluca Dinu³, Eric Miller³, Jonathan Mallari³, Giulio Cangin³ Norbert Keil², Hercules Avramopoulos¹, Norbert Grote² Electrical and Computer Engineering, National Technical University of Athens, Greece; ²Photonic Components, Fraunhofer Institute for Telecommunications - HHI, Germany, ³GigOptix Inc., USA.

We demonstrate for the first time monolithic and hybrid integration of complex passive and active InP elements on an electro-optic polymer platform. Using these elements we present a tunable laser and the optical part of a novel 100 Gb/s transmitter, revealing the potential of the material system to act as a multi-functional

integration platform.

P2.06 pg. 965 AN MMI-BASED POLARIZATION SPLITTER USING PATTERNED METAL AND TILTED JOINT

Wangqing Yuan^{1,2}, Keisuke Kojima¹, Bingnan Wang¹, Toshiaki Koike-Akino¹, Kieran Parsons¹, Satoshi Nishikawa³, Elji Yagyu³; ¹Mitsubishi Electric Research Laboratories, USA; ²University of Notre Dame, USA; ³Advanced Technology R&D Center, Mitsubishi Electric Corporation, Japan.

A novel polarization splitter on an InP substrate utilizing an MMI coupler with a patterned gold layer and a tilted joint is proposed. The MMI section is less than 540 µm. Simulations show that the device has a polarization extinction ratio over 23 dB and an insertion loss below 0.7 dB over the entire C-band for both TE and TM nolarizations

HALL 2 16:00-17:30 Joint Poster Session—Continued

P2.07 pg. 968 EXPERIMENTAL EVALUATION OF A PACKAGED SOI HYBRID ALL-OPTICAL WAVELENGTH CONVERTER IN A MESHED NETWORK TEST-BED

Christos Stamatiadis¹, Annachiara Pagano², Dimitrios Kalavrouziotis3, Roberto Morro2, Emilio Riccardi Kalavrouziotis⁻, koberto Morro-, Emilio Riccaru⁻, Leontios Stampoulidis⁺, Karsten Voig⁺, Giovani Preve⁵, Ludwig Moerl⁶, Jochen Kreiss⁶, Kennedy Landles⁷, Stephen Dufy⁻, Hercules Avramopoulos⁵, Lars Zimmermann^{8,1}, Klaus Petermann¹; ¹TUB, Greener ² Telecom Italia, Italy⁻, ¹ICCS/NTUA, Greece, ¹ Anophotonics Technology Center, Spain; ⁶HHI, Germany,² Optocap, United Kingdom; ⁸IHP, Germany, Germany.

We demonstrate data transmission and switching using a packaged and pigtailed all-optical wavelength converter The module employs a hybrid integrated SOA and two cascaded delay-interferometers on a 4µm SOI. We present wavelength routing with power penalties less than 5dB.

P2.08

P2.08 pg. 971 10-GB/S DIRECT MODULATION OF POLYMER-BASED TUNABLE EXTERNAL CAVITY LASERS Byung-Seok Chol^{1,3}, Su Hwan Oh¹, Ki Soo Kim¹, Ki-Hong Yoon¹, Hyun-Soo Kim¹, Mi-Ran Park¹, Jong-Sool Jeong¹,

OcKyun Kwon', Jun-Kyu Seo', Hak-Kyu Lee', Yun Chung', 'Electronics and Telecommunications Research Institute, Republic of Korea; 'ChemOptics Inc., Republic of Korea; 'Korea Advanced Institute of Science and Technology, Republic of Korea.

We demonstrate a directly-modulated 10-Gb/s tunable verternal cavity laser with a polymer Bragg reflector and a high speed superluminescent diode. 20 km transmission through the standard single mode fiber was carried out with a power penalty of less than 2.8 dB.

P2.09 pg. 974 EFFECTS OF SGDBR LASER PHASE NOISE ON COHERENT COMMUNICATION SYSTEMS Tam N. Huynh', Frank Smyth', Lim Nguyen', Liam Barry'; 'Rince Institute, School of Electronic Engineering, Dublin City University, Ireland; 'Department of Computer and Electronics Engineering, University of Nebraska-Lincoln, USA Lincoln, USA.

We investigate the effects of different phase noise processes of SGDBR laser on coherent systems at 5Gbaud. The SGDBR operated well with QPSK while performance of 16-QAM was significantly degraded due to excess noise.

P2.10 pg. 977 WDM SWITCHING EMPLOYING A HYBRID SILICON-PLASMONIC A-MZI Sotirios Papaioannou^{1,2}, Giannis Giannoulis³, Dimitrios

Kalavrouziotis3, Konstantinos Vyrsokinos2, Jan Claude Kalavouzous², Konstantinos vyrsoknios², Jan Odau Weeber¹, Karim Hassan², Laurent Markey⁴, Alain Dereux⁴, Ashwani Kumar⁶, Sergey Bozhevolnyi⁸, Dimitrios Apostopoulos³, Hercules Avramopoulos³, Nikos Pieros¹², ¹Department of Infromatics, Aristotle University of Thessaloniki, Greece; ²Informatics & Thessaloniki, ³Informatics & Thessaloniki, Telematics Institute, Center for Research & Technology Hellas, Greece: ³School of Electrical & Computer Figure 2, Greece, School of Electrical & Computer Engineering, National Technical University of Athens, Greece, ⁴Institut Carnot de Bourgogne, University of Burgundy, France, ⁵Institute of Technology and Innovation, University of Southern Denmark, Denmark.

We demonstrate a system-level evaluation of an A-MZI with 60µm long DLSPP active branches exhibiting more than 14dB extinction ratio. Error-free switching operation is achieved for a 4×10Gb/s incoming WDM data stream with only 13.1mW power consumption.

P2.11

P2.11 pg. 980 50-GBPS DIRECT MODULATION USING 1.3-MM ALGAINAS MQW DISTRIBUTE-REFLECTOR LASERS Takasi Simoyama¹, Manabu Matsuda¹, Shigekazu Okumura¹, Ayahito Uetake¹, Mitsuru Ekawa¹, Tsuyoshi Yamamoto¹; ¹*Fujitsu Laboratories Ltd., Japan.*

50-Gbps direct modulation is demonstrated for the first time using a short cavity 1.3-µm vavelength distributed-reflector laser. Clear eye openings with dynamic extinction ratios of 5 dB were obtained up to 50 degrees Celsius and 10-km fiber transmissions were confirmed

P2.12 pg. 983 PROPOSAL OF POLYMER THREE-DIMENSIONAL OPTICAL SWITCH AND DEMONSTRATION OF FUNDAMENTAL TRANSMISSION CHARACTERISTICS OF PASSIVE OPTICAL INTERCONNECTION CIRCUIT Takayuki Hoshina', Takuya Tatsuzaki', Genki Yuzawa', Hisaya Kobayashi', Yuichi Matsushima², Katsuyuki Utaka'; '*Faculty of Science and Engineering, Waseda* University, Japan; ²Green Computing Systems Research Organization, Waseda University, Japan.

We propose a 2x2 polymer three-dimensional optical switch and analyze the performance showing colorless and polarization-independent operation with a low-power consumption of about 2.9mW. We also experimentally demonstrate the fundamental transmission characteristics of a passive three-layered optical interconnection circuit

16:00-17:30 Joint Poster Session—Continued

16:00-17:30

A MONOLITHICALLY INTEGRATED TUNABLE LASER WITH SINGLE STRIPE STRUCTURE Aaron Albores-Mejia¹, Haruhiko Kuwatsuka¹, Hajime Shoji², Hiroshi Ishikawa¹; ¹Network Photonic Reseach Center, National Institute of Advanced Industrial Science and Technology (AIST), Japan; ²Sumitomo Electric Industries, Japan.

P2.13 pg. 986 FULL-BAND INJECTION-LOCKING PROPERTIES OF

Full-band injection-locking properties of a high power, low phase noise, tunable monolithically integrated CSG-DR-LD are investigated. An average injection-locking range of 2.5GHz at optical injection ratios of -22dB is obtained. These characteristics make the CSG-DR-LD a highly promising light source for future tunable coherent receivers

P2.14 pg. 989 SPATAL MODE-DIVISION-MULTIPLEXING OF FEW-MODE FIBER Nicolas Riesen¹, John D. Love², ¹RSPE, The Australian National University, Australia, ²PEC, The Australian National University, Australia.

The independent excitation and detection of spatial modes in few-mode fiber networks presents major challenges. This paper presents novel spatial mode-division-multiplexing techniques based on planar couplers and asymmetric Y-junctions. These developments may play a role in future high-capacity few-mode fiber telecommunications.

P2.15

P2.13

P2.15 pg. 992 1.3 MM INAS/GAAS QUANTUM DOT LASERS 1.3 MM INAS/GAAS GUANTOM DO'LASERS ON SI RIB STRUCTURES WITH CURRENT INJECTION ACROSS DIRECT-BONDED GAAS/SI HETEROINTERFACES

Katsuaki Tanabe¹, Katsuvuki Watanabe¹, Yasuhiko Arakawa¹2; ¹Institute for Nano Quantum Information Electronics, University of Tokyo, Japan; ²Institute of Industrial Science, University of Tokyo, Japan.

A 1.3 µm room-temperature InAs/GaAs quantum dot laser on a Si rib structure is demonstrated. The laser structure grown on a GaAs substrate is layer-transferred onto a patterned Si substrate by GaAs/Si direct wafer bonding without oxide or metal mediation, realizing current injection through the Si rib.

P2.16 pg. 995 EFFICIENT SECOND HARMONIC GENERATION IN PHOTONIC CRYSTAL WAVEGUIDES FOR OPTICAL PERFORMANCE MONITORING IN THE FULL C-BAND AT 42.5 GB/S

Kevin Lengle¹, Laurent Bramerie¹, Mathilde Gay¹, Jean Claude Simon', Sylvani Combrié', Lehoucq Gaelle', S. Xavier', Alfredo De Rossi?; ¹CNRS FOTON UMR 6082, France; ²Thales Research and Technology, France.

We demonstrate 20 µW second harmonic generation in a photonic crystal waveguide. The collected signal has been used for optical performance monitoring of the chromatic dispersion and optical signal to noise ratio of a 42.5 Gb/s Return to Zero signal all over the C-band.

P2.17

P2.17 pg. 998 ALL-OPTICAL LATCH AND GATE PULSE RELEASE TO A CONTRACT OF THE SECOND OF THE S

40GBPS OPERATION Yusuke Naito', Satoshi Shimizu', Tomoyuki Kato', Kohroh Kobayashi', Hiroyuki Uenohara', '*Precision and* Intelligence Laboratory, Tokyo Institute of Technology, Japan.

We achieved latch and gate pulse generation in a monolithically integrated semiconductor-optical-amplifierbased Mach-Zehnder interferometer-type set/reset flip-flop using ultrashort pulses. The operation of the device with 18-ps optical pulses for 40Gbps operation was verified under the condition of slow carrier recovery condition.

P2.18 pg. 1001 CONCEPT OF A PHOTONIC INTEGRATED SPATIAL MODE MULTIPLEXER/ DEMULTIPLEXER CHIP FOR FMF TRANSMISSION

Abdullah Al Amin', An Li', William Shieh'; 'Dept. of Electrical and Electronic Engineering, The University of Melbourne, Australia.

We propose a photonic-integrated-circuit design fo spatial mode multiplexer and demultiplexer based on multi-mode interference and a micro-optic component. The MIMO channel condition is evaluated for the proposed mode multiplexer/demultiplexer combination

P2.19 pg. 1004 MONOLITHICALLY INTEGRATED INTERSUBBAND ALL-OPTICAL SWITCH USING AREA-SELECTIVE ACTIVATION OF CROSS-PHASE MODULATION IN INGAAS/ALASSB QUANTUM WELLS

We developed a compact gate switch with monolithin We developed a compact gate switch with monointic integration of all-optical cross-phase modulation (XPM) in a Mach-Zehnder interferometer, by area-selective implantation for intersubband transition in InGaAs/ AIASSb CDOWs. By injecting pump light through a TE/ TM beam combiner, XPM was induced in one MZI arm, and gating operation was realized.

P2.20 pg. 1007 SINGLE-MODE POLYMER OPTICAL INTERCONNECTS FOR SI PHOTONICS WITH HEAT RESISTANT AND LOW LOSS AT 1310/1550NM Shotaro Takenobu¹, Yuriko Kaida¹; ¹Asahi Glass, Jap

We demonstrated single-mode fluorinated polymer optical waveguides for Si photonics of chip-to-chip. We estimated the propagation loss by cut back method. They are 0.28/0.38dB/cm at 1310/1550 nm. The reliability and heat resistance were also evaluated. The results show good performance.

SC3: Subsystems for Optical Networks

P3.01 pg. 1010 NONLINEAR MITIGATION USING CARRIER PHASE ESTIMATION AND DIGITAL BACKWARD PROPAGATION IN COHERENT QAM TRANSMISSION

PROPAGATION IN COHERENT QAM TRANSMISSI Chien-Yu Lini², Rameez Asir², Michael Holtmannspoetter¹², Bernhard Schmauss¹², ¹Chair of High Frequency Technology, University of Erlangen-Nuremberg, Germany,² Erlangen Graduate School in Advanced Optical Technologies (SAOT), Germany.

We investigate the performance of carrier phase ve investigate upperformance of carrier prose-estimation (CPE) and digital backward propagation (DBP) in compensating fiber nonlinearity for 224Gbps PM-4QAM and PM-16QAM coherent systems. In the presence of CPE, the number of DBP steps can be reduced.

16:00-17:30 Joint Poster Session—Continued

P3.02 P3.02 pg. 1013 COMPLEX DECISION-AIDED MAXIMUM-LIKELIHOOD PHASE NOISE AND FREQUENCY OFFSET COMPENSATION FOR COHERENT OPTICAL RECEIVERS

Adaickalavan Meiyappan¹, Pooi-Yuen Kam¹, Hoon Kim¹; ¹Department of Electrical and Computer Engineering, National University of Singapore, Singapore.

We present a novel complex decision-aided maximum likelihood receiver for joint phase noise and frequency offset compensation, with automatic on-line filter weight adaptation using a least-sum-of-squared-error criterion Frequency offset is acquired quickly and compensated perfectly for a complete frequency offset range of ±1 times the symbol rate.

P3.03 pg. 1016 FULL-ADD/DROP C/D/C-LESS ROADM ACHIEVED BY DEVELOPING ARRAYED OPTICAL AMPLIFIERS WITH A SHARED PUMP LASER

Yohei Sakamaki¹, Takeshi Kawai¹, Mitsunori Fukutoku¹, Tomoyoshi Kataoka', Kenya Suzuki'; INTT Network Innovation Laboratories, NTT Corporation, Japan; ²NTT Photonics Laboratories, NTT Corporation, Japan.

We demonstrate the feasibility of arrayed optical amplifiers sharing a single pump laser to realize full-add/ drop C/D/C-less ROADM nodes. Experimental results show that the arrayed optical amplifiers corresponded properly to the wavelength path reconfigurations by adjusting the splitting ratio of the splitter between the pump laser and eight EDFAs.

P3.04 pg. 1019 SPECTRALLY EFFICIENT AND HIGH EXTINCTION RATIO DPSK/ASK ORTHOGONAL MODULATION SCHEMES BASED ON INJECTION LOCKING LIMITING AMPLIFIERS

Alexandros M. Fragkos¹, Adonis Bogris^{1,2}, Dimitris Syvridis¹; ¹Department of Informatics and Telecommunications, National and Kapodistrian University of Athens, Greece; ²Department of Informatics,

Technological Educational Institute of Athens, Greece We experimentally demonstrate a novel receiver architecture based on injection locking for demodulating DPSK/ASK modulated signal with ASK extinction ratio exceeding 8 dB. The receiver exploits the limiting amplification of injection locking and enhances the

performance of the DPSK stream.

P3.05 pg. 1022 PERFORMANCE EVALUATION OF A SOA-BASED RACK-TO-RACK SWITCH FOR OPTICAL INTERCONNECTS EXPLOITING NRZ-DPSK Fotini Karinou¹², Robert Borkowski², Kamau Prince², Ioannis Roudas¹, Idelfonso Tafur Monroy², Kyriakos Vachos^{*}, ¹Dept. of Electrical & Computer Engineering, University of Patras, Greece^{*}, ²Dept. of Photonics Engineering, Technical University of Denmark, Denmark; ³Dept. of Computer Engineering & Informatics, University of Patras, Greece.

We experimentally study the transmission performance of 10-Gb/s MRZ-DPSK through concatenated AWG MUX/ DMUXs and SOAs employed in an optimized 64×64 optical supercomputer interconnect architecture. NRZ-DPSK offers 9-dB higher dynamic range compared to conventional IM/DD.

P3.06 pg. 1025 EVALUATION OF CORRELATIVE CODING AND DP-16QAM N-CHANNEL 112GBIT/S COHERENT TRANSMISSION: DIGITAL NON-LINEAR

COMPENSATION PERSPECTIVE Rameez Asif^{1,2}, Chien-Yu Lin^{1,2}, Michael Holtmannspoetter^{1,2}, Bernhard Schmauss^{1,2}, ¹Chair of High Frequency Technology (LHFT), University of Erlangen-Nuremberg, Germany, Germany, ²Erlangen Graduate School in Advanced Optical Technologies (SAOT), Germany.

We report on the complexity reduction of digital backward propagation (DBP) by utilizing correlative encoded transmission over 1640km fiber link. Comparative system performance wirt DP-16OAM transmission can be achieved with 60% less computations and with a step size of 205km.

P3.07 P3.07 pg. 1028 OPTICAL PHASE REGENERATION OF MULTI-

LEVEL PSK USING DUAL-CONJUGATE-PUMP DEGENERATE PHASE-SENSITIVE AMPLIFICATION Jeng-Yuan Yang', Youichi Akasaka', Motoyoshi Sekiya', 'Fujitsu Laboratories of America, USA.

We propose a PSA scheme employing bi-directional signal-conjugate generations and then dual-conjugate-pump FWM for phase regeneration of QPSK/8PSK and potentially 16PSK. We show effective reductions on phase noise deviation by 5.2 and 8.5 degrees for 25-Gbaud/s 8PSK and QPSK and verify its scalability at 50-Gbaud/s

P3.08 pg. 1031 A CIRCUIT ENABLING CLOCK EXTRACTION IN COHERENT RECEIVERS Nebojas Stojanovic', Changsong Xie', Yu Zhao', Bangning Mao', Neil Guerrero Gonzalez'; 'Huawei,

Germany

We present a method for clock extraction in polarization domain timing phase detector. The phase detector input signal is pre-processed using a simplified polarizer transfer function enabling the maximum clock tone quality

P3.09

P3.09 pg. 1034 ULTRA-LOW TIMING-JITTER 40GHZ CLOCK RECOVERY USING EAM-MZM DOUBLE-LOOP AND ITS APPLICATION IN A 640GBIT/S OTDM SYSTEM Deming Kong', Hui Wang', Yan Li', Jizhao Zang', Siyuan Zhou', Xixue Jia', Jian Wu', Jintong Lin'; 'State Key Laboratory of Information Photonics and Optical

Communications, Beijing University of Posts and Telecommunications, China. 35fs timing-jitter clock recovery based on EAM-MZM

double-loop with ability of simultaneous demultiplexing is proposed to enable a 640Gbit/s-400km OTDM transmission system with power penalty of 4dB. Results show significant performance improvement compared with MZM-OEO based clock recovery in system

P3.10 pg. 1037 ON THE OPTIMIZATION OF LINK DESIGN USING NONLINEAR EQUALIZATION FOR 100GB/S 16QAM

TRANSMISSION Roi Rath¹, Jochen Leibrich¹, Werner Rosenkranz¹; ¹University of Kiel, Germany.

The reduction of the number of EDFAs in a transmission link using nonlinear equalization was investigated for a 25GBaud RZ50-16QAM transmission. Nonlinear equalization was found to reduce the amount of EDFAs by up to 50% in comparison with linear equalization, depending on the type of fiber and the sampling rate of receiver ADC.

P3.11 pg. 1040 ANALYTICAL RESULTS ON BACK PROPAGATION NONLINEAR COMPENSATOR IN COHERENT TRANSMISSION SYSTEMS Takahito Tanimura', Markus Nolle', Johannes Karl

Fischer¹, Colja Schubert¹; ¹Department of Photonic Networks and Systems, Fraunhofer Institute for Telecommunications Heinrich Hertz Institute, Germany

We derive analytic formulas for SNR improvement by a digital nonlinear compensator for uncompensated links by using a four-wave mixing approach. The improvement only depends on fiber parameters as well as on total and received bandwidth. We discuss dependency of the improvement on fiber type and validate the analysis by numerical simulations.

P3.12 pg. 1043 A FULL-DUPLEX DIGITIZED ROF SYSTEM FOR MILLIMETER-WAVE OFDM TRANSMISSION Yizhuo Yang', Christina Lim', Ampalavanapillai Nirmalathas'; 'The University of Melbourne, Australia.

We propose and demonstrate a full-duplex digitized RoF link for millimeter-wave OFDM transmission with minimal crosstalk. It enables using low-bandwidth optoelectronic devices for the transmission of 1-GHz bandwidth millimeter-OFDM signal via 10-Gbps digital optical link using ADC/DAC with 1-GHz sampling rate.

P3.13 pg. 1046 12.5-GBIT/S BPSK STABLE OPTICAL HOMODYNE DETECTION USING 3-KHZ SPECTRAL LINEWIDTH EXTERNAL-CAVITY LASER DIODE

Akira Mizutori¹, Masamichi Sugamoto¹, Masafumi Koga¹; ¹Electrical and Electronics Engineering, Oita University, Japan.

. his paper demonstrates 12.5-Gbit/s BPSK decision-directed homodyne detection. We design a phase-locked loop adopted injection-current controlled laser diode oscillator and its phase terror to achieve the standard deviation of 2° . Owing to this phase-look performance, the receiver sensitivity matches that of a digital coherent receiver

16:00-17:30 Joint Poster Session—Continued

16:00-17:30

P3.14 pg. 1049 FLEXIBLE, RECONFIGURABLE CAPACITY OUTPUT OF A HIGH-PERFORMANCE 64-QAM OPTICAL TRANSMITTER

Mohammad Reza Chitgarha¹, Salman Khaleghi¹, Zichen Ma¹, Morteza Ziyadi¹, Ori Gerstel², Loukas Paraschis², Carsten Langrock³, Martin Fejer³, Alan Willner¹;
 ¹University of Southern California, USA; ²Cisco Systems, USA; ³Stanford University, USA.

We experimentally demonstrate a reconfigurable optical flexible transmitter to generate arbitrary optical QAM. Optical 16-QAM and 64-QAM is generated at EVM 8.5% and 7.2% respectively. We demonstrated successful transmission through 80-km SMF-28 after compensating with 20-km DCF with negligible penalty.

P3.15 pg. 1052 OPTICALLY-FILTERED LASER SOURCE ENABLING IMPROVED PHASE TRACKING IN COHERENT TRANSMISSION SYSTEMS Wing Chau Ng¹, An Truong Nguyen¹, Simon Ayotte², Chul Soo Park¹, Leslie Rusch¹, 'Electrical Engineering, Universite Laval, Canada: ²TeraXion, Canada.

We report phase tracking performance using an external cavity laser with and without optical filtering of high-frequency phase noise with an ultra-narrowband fiber Bragg grating. Phase tracking improvement is characterized when using a commercial, integrated coherent receiver. Noise suppression reduces tracking variance in a Wiener filter by 5 dB.

P3.16 pg. 1055 TRAINING-BASED CHANNEL ESTIMATION FOR

TRAINING-BASED CHANNEL ESTIMATION FOR SIGNAL EQUALIZATION AND OPM IN 16-QAM OPTICAL TRANSMISSION SYSTEMS Fabio Pittalà¹², Fabian N. Hauske¹, Yabin Ye¹, Idelfonso Tafur Monroy², Josef A. Nossek¹; ¹European Research Center, Huawei Technologies Dusseldorf GmbH, Germany; ²DTU Fotonik, Technical University of Denmark, Denmark; ¹Institute for Circuit Theory and Signal Processing, Technische Universität München, Germany Germany.

Efficient channel estimation for signal equalization and OPM based on short CAZAC sequences with QPSK and 8PSK constellation formats is demonstrated in a 224-Gb/s PDM 16-QAM optical linear transmission system.

P3.17 pg. 1058 EXPERIMENTAL DEMONSTRATION OF A COST-EFFECTIVE BIT RATE VARIABLE INTENSITY MODULATION AND DIRECT DETECTION OPTICAL OFDM WITH REDUCED GUARD BAND

Michela Svaluto Moreolo¹, Josep Fabrega¹, Fco. Javier Vilchez¹, Laia Nadal¹, Gabriel Junyent¹; ¹Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain.

We experimentally demonstrate an intensity modulated and direct detection optical OFDM with variable bit rate and one detection optical OPDM with variable on rate from 5G/b to 8G/b using BPSK format and reducing the guard band up to 75% over 25km SSMF. A fast processing based on Hartley transform is performed achieving the same performance as 4QAM FFT-based processing with low complexity DSP.

SC4: Transmission Systems and Network Elements

P4.01 pg. 1061 SPECTRAL SHAPING TRADEOFFS IN ROOT-RAISED-COSINE PDM-QPSK NONLINEAR TRANSMISSION

Petros Ramantanis', Aida Seck¹, Jordi Vuong¹, Djalal Bendimerad¹, Yann Frignac¹; ¹Electronics and Physics, Telecom SudParis, France.

We numerically investigate the WDM performance of RRC-PDM-QPSK systems, for variable dispersion management and channel spacing. We point out the optimal roll-off factors after nonlinear transmission and discuss the resulting trade-offs between spectral efficiency and performance.

P4.02 pg. 1064 REAL-TIME PROCESSED 34 X 120 GB/S TRANSMISSION OVER 432.8 KM UNREPEATERED LINK WITH LEGACY FIBER AND SPAN LOSS OF 74.4DB

Do-il Chang¹, Pallavi Patki¹, Sergey Burtsev¹, Wayne Pelouch1; 1Xtera Communications, Inc, USA

Unrepeatered transmission of 34 x 120 Gb/s PM-NR7 QPSK signal over 432.8 km of standard effective-area pure-silica-core fiber (74.4 dB) is achieved using forward and backward distributed Raman amplification and remotely-pumped erbium fiber. Transmission has been demonstrated using a commercial 100G channel card with real-time ASIC processor.

P4.03 pg. 1067 614 MBIT/S OOK-BASED TRANSMISSION BY THE DUOBINARY TECHNIQUE USING A SINGLE COMMERCIALLY AVAILABLE VISIBLE LED FOR HIGH-SPEED VISIBLE LIGHT COMMUNICATIONS Nobuhiro Fujimoto¹, Hikari Mochizuki¹; ¹Kinki University,

lanan We have first performed 614 Mbit/s OOK-based

transmission experiments using the duobinary technique of a single commercially available visible LED by adopting pre-emphasis and post-equalizing circuits with simple RC networks.

P4.04 pg. 1070 UNREPEATERED 8 X 40GB/S TRANSMISSION OVER 320KM SMF-28 USING ULTRA-LONG RAMAN FIBRE BASED AMPLIFICATION

Pawel Rosa¹, Paul Harper¹, Neil Murray¹, Juan-Diego Ania-Castanon²; ¹Aston Institute of Photonic Technology, United Kingdom; ²Instituto de Óptica, IO-CSIC, Spain.

Unrepeatered transmission over SMF-28 fibre is investigated using ultra-long Raman fibre laser based amplification. Experiments and simulations demonstrate 8 x 42.76b/s transmission up to 320km (67dB) span length using DPSK and ASK modulation with direct detection

P4.05 pg. 1073 PHASE NOISE ROBUSTNESS OF SIM-OFDM IN CO-

OFDM TRANSMISSION OFDM TRANSMISSION Omar Jan', David Sandel', Mohamed El-Darawy', Kidsanapong Puntsri', Ali Al-Bermani', Reinhold Noé'; 'University of Paderborn, Germany.

We present the robustness of subcarrier-index modulation OFDM to combat laser phase noise. Simulation results show the ability of using DFB lasers with SIM-OFDM in 16-QAM CO-OFDM system with 1024-point FFT.

P4.06 pg. 1076 DETECTION STRATEGIES IN THE PRESENCE OF FIBER NONLINEAR EFFECTS Domenico Marsella¹, Marco Secondini¹, Enrico Forestieri¹, Roberto Magri²; ¹*Tecip, Scuola Superiore* Sant'Anna, Italy; ²*Ericsson, Italy.*

All known compensation techniques for combating fiber nonlinearities, including digital back- propagation (BP), are far from being optimal. However, it is shown that a low-complexity Viterbi detector with proper metrics is a good alternative or complement to BP for approaching optimal performance.

P4.07 pg. 1079 FORWARD ERROR CORRECTION TRADE-OFFS IN REDUCED-LATENCY OPTICAL FIBER TRANSMISSION SYSTEMS

Brian T. Teipen¹, Mark Filer¹, Helmut Griesser², Michael Eiselt³, Jörg-Peter Elbers²; ¹*ADVA Optical Networking*, USA; ²ADVA Optical Networking, Germany; ³ADVA Optical Networking, Germany.

100G DP-QPSK transmission can use programmable SD-FEC to trade-off latency against coding gain. Albeit inferior to 10G ultra-low latency implementations, such a solution can approach state-of-the art 10G G.709 FEC transmission in latency and performance while offering a 10x capacity increase

P4.08 pg. 1082 CROSSTALK TOLERANCE OF SPATIALLY

MULTIPLEXED MIMO SYSTEMS Sebastian Randel¹, Alberto Sierra¹, Roland Ryf¹, Peter Winzer¹; ¹Bell Laboratories, Alcatel-Lucent, USA. We assess the tolerance of an optical MIMO system to crosstalk from other, nominally isolated MIMO systems to trade optical component crosstalk specifications with MIMO digital signal processing complexity in spatially multiplexed transmission.

P4.09 pg. 1085 100 GB/S UNCOOLED WDM SYSTEM USING CONVENTIONAL WDM COMPONENTS AND ADVANCED RECEIVER SIGNAL PROCESSING Jonathan D. Ingham', S. H. Lee', Richard V. Penty', Ian H. White', David G. Cunningham?; 'Department of Engineering, University of Cambridge, United Kingdom; 'Avago Technologies, United Kingdom;

We demonstrate an uncooled WDM system using standard WDM components and receiver signal processing, with a different number of receivers to transmitters, to allow wide temperature drift of the transmitter lasers. A 100 Gb/s 8-wavelength demonstrator has been developed, which proves the feasibility of the approach over 25 km of SMF.

P4.10 pg. 1088 TCM-QPSK PERFORMANCE IN SUBSEA TRIALS Pierre Mertz¹, Emily Burmeister¹, Hai Xu¹, Vince Dominic¹, Han Sun¹, Kuang-Tsan Wu¹, Steve Grubb¹, Dave Welch¹; ¹*Infinera, USA*.

Trellis Coded Modulated (TCM)-QPSK has been demonstrated as a coherent optical modulation format. For the first time its performance is compared to BPSK on four subset segments of different lengths, showing performance benefits of up to 1.8 dB.

16:00-17:30 Joint Poster Session—Continued

P4.11 pg. 1091 625 GBIT/S SUPERCHANNEL CONSISTING OF INTERLEAVED DP-16QAM AND DP-QPSK WITH 4.17 BIT/S/HZ SPECTRAL EFFICIENCY

Tobias A. Eriksson¹, Ekawit Tipsuwannakul¹, Jianqiang Li¹, Magnus Karlsson¹, Peter A. Andrekson¹; ¹Photonics Laboratory, Microtechnology and Nanoscience, Chalmers University of Technology, Sweden.

We experimentally investigated a superchannel consisting of 25 GHz spaced interleaved 3x18.67 GBaud DP-OPSK and 3x18.67 GBaud DP-16QAM. We showed a 0.3 dB improvement in the Q-value averaged over the center two channels compared to an all DP-16QAM superchannel with the same SE after transmission over 480 km and 560 km of SSMF.

P4.12 pg. 1094 SEMI-ANALYTICAL MODEL FOR THE NONLINEAR INTERFERENCE IN MODE MULTIPLEXED MULTI-MODE FIBERS

Georg Rademacher¹, Stefan Warm¹, Klaus Petermann¹; Hochfrequenztechnik. Technische Universität Berlin Germany

We present a semi-analytical method to study the nonlinear interaction in mode multiplexed multi-mode fibers. By employing a four-wave-mixing based Gaussian-noise signal model, we investigate the nonlinear effects on the OSNR. We discuss certain fiber parameters as options to control intra- and intermodal nonlinear crosstall

P4.13 pg. 1097 MITIGATION OF PDL IN COHERENT OPTICAL COMMUNICATIONS: HOW CLOSE TO THE FUNDAMENTAL LIMIT? Pierre Delesques^{1,2}, Elie Awwad², Sami Mumtaz³, Gwillerm Froc¹, Philippe Ciblat², Yves Jaouën², Ghaya Rekaya², Cédric Ware³, 'System, Network and Services, Mitsubishi Electrics R&D Centre Europe, France; ²Communications & Electronique, Institut Telecom/ Telecom Paris Tech, France; 'Institute of Optics, University of Rochester, USA.

Considering coherent optical transmissions with PDL disturbance, we evaluate how far from the fundamental limit (based on the outage probability) are conventional coding schemes using Polarization-Time codes and/or LDPC codes.

HALL 2

P4.14 pg. 1100 THE LIMITS OF DIGITAL BACKPROPAGATION IN NONLINEAR COHERENT FIBER-OPTICAL LINKS Lotfollah Beygi', Erik Agrell', Pontus Johannisson²,

Magnus Karlsson², Henk Wymeersch¹; ¹Signals and Systems Dept., Chalmers University of Technology, Sweden; ²Photonics Laboratory, Chalmers Univer Technology, Sweden. rsity of

The performance of a single-channel fiber-optical link is evaluated with linear (dispersive) and nonlinear equalization. The results show a quadratic growth of

the noise variance with input power for a system with nonlinear equalization and also justify the known cubic growth for linear equalization.

P4.15 pg. 1103 IMPACT OF MIXING RATIO AND PLACEMENT OF SMF AND LARGE AEFF PSCF ON 448 GB/S 2SC-DP-16QAM TRANSMISSION

16QAM TRANSMISSION Shoichiro Oda', Kyosuke Sone², Yasuhiko Aoki¹, Yuichi Akiyama', Takeshi Hoshida', Jens C. Rasmussen', Yoshinoi Yamamoto², Takashi Ssaaki¹, Fujitsu Limited, Japan; ²Fujitsu Laboratories Ltd., Japan; ³Sumitomo Electric Industries, Ltd., Japan.

We experimentally investigate transmission performance of 448 Gb/s two sub-carrier DP-16QAM over mixed large-Aeff pure silica core fibre and standard SMF link and demonstrate performance dependency on fibre connection order as well as mixing ratio.

P4.16 pg. 1106 2.1 GBIT/S VISIBLE OPTICAL WIRELESS TRANSMISSION

Giulio Cossu¹, Amir M. Khalid¹, Pallab Choudhury¹, Raffaele Corsini¹, Ernesto Ciaramella¹; '*Scuola Superiore* Sant'Anna, Italy.

We demonstrate gigabit-class indoor visible optical wireless transmission using commercial components and DMT modulation of a common visible RGB LED. We obtained 1 Gbit/s single channel and 2.1 Gbit/s WDM transmission at usual illumination levels.

P4.17 pg. 1109 DUAL-POLARIZATION MULTI-BAND OFDM VERSUS SINGLE-CARRIER DP-QPSK FOR 100 GBPS LONG-HAUL WOM TRANSMISSION OVER LEGACY INFRASTRUCTURE

INFRASTRUCTURE Julie Karaki, Erwan Pincemin¹, Didier Grot¹, Thierry Guillossou¹, Yves Jaouën², Raphael Le Bidan³, Thierry Le Gall¹, ¹CORE/TPN, France Telecom, Orange Labs, France; ¹Telecom Paris Tech, Institut Telecom, France; ³Telecom Bretagne, Institut Telecom, France.

We compare the performance of CO-DP-MB-OFDM and CO-DP-QBS for 100 Gbps long-hall transport over legacy infrastructure combining G.652 fiber and 10Gbps WDM system. We show that they have nearly the same performance at 100Gbps after transmission over a 10x100-km fiber line.

P4.18 pg. 1112 SCALING THE ADVANTAGES OF INTRA-CHANNEL NONLINEARITY COMPENSATION IN FUTURE FLEXIBLE OPTICAL NETWORKS

Danish Rafique¹, Andrew Ellis¹: ¹Photonic Systems Group, Tyndall National Institute, Ireland, Ireland.

We report that, contrary to common perception, intra-channel nonlinearity compensation offers significant improvements of up to 4dB, in nonlinear tolerance (Q-factor), in a flexible traffic scenario, and further Improvements with increasing local link dispersion, for an optical transport network employing flexible 28Gbaud PM-mQAM transponders.

P4.19 pg. 1115 CASTING 1 TB/S DP-QPSK COMMUNICATION INTO

CASTING 1 TB/S DP-QPSK COMMUNICATION INTC 200 GHZ BANDWIDTH Luca Poti¹, Gianluca Meloni², Gianluca Berrettini², Francesco Fresi², Marco Secondin², Tommaso Foggi³ Giulio Colavolge³, Enrico Forestier², Annoio D'Errico³, Fabio Cavaliere⁴, Roberto Sabella⁴, Giancarlo Trati²; Photonic Networks National Laboratory, CNIT, Italy; ²TECIP, Scuola Superiore Sant'Anna, Italy; ³Research Unit at University of Parma, CNIT, Italy; ⁴Research, Italy, Ericsson Telecomunicazioni S.p.A., Italy.

We demonstrate the feasibility of a novel time Trequency packing technique to implement DPOPSK communication with a record spectral efficiency ranging from 5.14 to 4.3 bit/sHz over a distance ranging from 3000 km to 5200 km of uncompensated standard fiber, respectively

16:00-17:30 Joint Poster Session—Continued

16:00-17:30 SC5: Backbone and Core Networks

P5.01 pg. 1118 EXPERIMENTAL SETUP FOR OPENFLOW-BASED ELASTIC LIGHTPATH PROVISIONING IN FLEXI-GRID OPTICAL NETWORKS

Jiawei Zhang¹, Jie Zhang¹, Yongli Zhao¹, Hui Yang¹, Xiaosong Yu¹, Lei Wang², Xihua Fu², '*Beijing University* of Posts and Telecommunications, State Key Laboratory of Information Photonics and Optical Communication. China; 2ZTE Corporation, China.

We propose an OpenFlow-based control plane for elastic lightpath provisioning in Flexi-Grid optical networks and experimentally demonstrate its feasibility of dynamic spectrum adjustment with OpenFlow protocol. The overall latency including signaling and hardware for lightpath setup and adjustment are reported.

P5.02 pg. 1121 INTER-LAYER TRAFFIC ENGINEERING WITH HIERARCHICAL-PCE IN MPLS-TP OVER WAVELENGTH SWITCHED OPTICAL NETWORKS Ramon Casellas', Ricardo Martínez', Raul Muñoz', Lei Liu², Takehiro Tsuritani², Ilsuro Morita²', Optical Networking Area, CTTC, Spain; ²Photonic Transport Network Laboratory, KDDI R&D Laboratories, Japan.

We present the implementation and validation of an Interlayer Traffic Engineering architecture based on a Hierarchical PCE where the p-PCE is notified of optical layer LSPs which become packet TE links, not requiring full topology visibility. We summarize the architecture, the control plane extensions and its experimental evaluation in a testbed

P5.03 pg. 1124 DIGITAL BIT-ERROR-RATE MONITORING AND SOFT LINK-FAULTS DIAGNOSIS FOR DYNAMIC ALL-OPTICAL WDM NETWORK

Huadong Li¹, Jie Zhang², Kwok-shing Ho³, Kwok-wai Cheung¹; ¹IE, CUHK, China; ²State Key Laboratory of Information Photonics and Optical Communications BUPT, China; 3Huawei Corporate Research, China

A new approach for monitoring dynamic all-optical WDM networks without incurring additional hardware is proposed by modeling the problem using linear three built is a set of the problem using l programming. It can be easily implemented by extending programming. It can be easily implemented by extending the OSPF-TE protocol. The feasibility and stability are demonstrated by simulation of a 408-node multi-domain network with ten soft link-faults.

P5.04 pg. 1127 A HITLESS DEFRAGMENTATION METHOD FOR SELF-OPTIMIZING FLEXIBLE GRID OPTICAL NETWORKS

Xi Wang¹, Inwoong Kim¹, Qiong Zhang¹, Paparao Palacharla¹, Motoyoshi Sekiya¹; ¹Fujitsu Labs of America USA.

We present an auto-defragmentation method to continuously 'defrag' flexible grid optical networks without service disruption. Signal dependency map is introduced to identify candidate signals to be retuned and their retune sequence. Simulation results show up to 76% reduction in request blocking and 38% reduction in the number of stranded slots

P5.05 pg. 1130 ON THE ENERGY EFFICIENCY OF SURVIVABLE OPTICAL TRANSPORT NETWORKS WITH FLEXIBLE-GRID

FLEXIBLE-GRID Jorge Lopez Vizcaino^{1,3}, Yabin Ye¹, Victor López², Felipe Jiménez², Raúl Duque², Peter Krummrich³, ¹Huawei Technologies Duesseldorf GmbH, European Research Center, Germany, ²Teléñnica I+D, Spain, ³Technische Universitaet Dortmund, Germany.

An energy efficiency comparison of conventional path protection schemes for fixed-grid WDM and flexible-grid OFDM-based networks has been carried out. The survivable elastic network with SP scheme was found to offer the best energy efficiency per GHz at any traffic load value

P5.06 P5.06 pg. 1133 POWER CONSUMPTION ANALYSIS OF

ARCHITECTURE ON DEMAND Miquel Garrich', Norberto Amaya', Georgios Zervas², Paolo Giaccone', Dimitra Simeonidou², '*CNIT and* Dipartimento di Elettronica e Telecomunicazioni, CNIT-PoliTo, Italy; ²School of Computer Science and Electronic Engineering, University of Essex, United Kingdom.

Recently proposed Architecture on Demand (AoD) node shows considerable flexibility benefits against traditional ROADMs. We study the power consumption of AoD including sub-wavelength time switching functionality. Results show that AoD can bring energy savings at node

P5.07 pg. 1136 NETWORK MODELLING AND TECHNO-ECONOMIC ANALYSIS OF OPTICAL BURST RING FOR METROPOLITAN APPLICATIONS Ning Deng', Qingsong Xue', Mo Li', Andrew Lord², Peter Willis', Shiyi Cao', Zhiyong Feng', 'Networks Research Department, Huawei Technologies, China; ²BT Research and Technology, United Kingdom.

We model optical burst ring networks and perform techno-economic analysis based on real-world metro networks. The study shows the optical burst ring significantly reduces cost and power consumption, as compared with optical circuit networking schemes

P5.08 pg. 1139 ENERGY-EFFICIENCY OPTIMISED UPGRADE PATHS FOR CASCADED, STOCHASTICALLY-BASED, MASTER-SLAVE IP ROUTER CONFIGURATIONS Michael C. Parker', Stuart Walker'; 'CSEE, University of Essex, United Kingdom.

We present a novel design rule offering maximally we present a flower design flow plotting industry energy-efficient and future-proofed TD/S--DPIs upgrade paths for IP routers. One path assumes 10% average Poisson traffic intensity with 68.1% energy-efficiency gains over only 5 upgrade generations; while 30% average traffic load only enables 45.7% energy-efficiency gains and requires 9 generations.

P5.09 pg. 1142 ON THE COEXISTENCE OF MULTI-CHANNEL 100 GB/S ETHERNET WITH LEGACY SINGLE-CHANNEL SERVICES IN METROPOLITAN NETWORKS

Jao Santos^{1,2}, Gottfried Lehmann¹, João Pedro^{1,2}; ¹Nokia Siemens Networks, Portugal; ²Instituto de Telecomunicações, Portugal; ³Nokia Siemens Networks, Germany.

We study the effectiveness of deploying 100Gb/s Ethernet services using parallel 4x28Gb/s channels in metropolitan networks already supporting legacy single-channels services. The successful set up of these services is shown to heavily depend on the planning methodology, multi-channel transponder tunability, and single-channel services load share

16:00-17:30 Joint Poster Session—Continued

P5.10 pg. 1145 DYNAMIC SPECTRAL DEFRAGMENTATION BASED ON PATH CONNECTIVITY IN FLEXIBLE BANDWIDTH

Ying Wang¹, Jie Zhang¹, Yongli Zhao¹, Jiawei Zhang¹, Jie Zhao¹, Xinbo Wang¹, Wanyi Gu¹, ¹Beijing University of Posts and Telecommunications, China.

A novel dynamic defragmentation algorithm MPC (Maximize Path Connectivity) is proposed based on the notion of Path Connectivity. Simulation results show that the proposed algorithm reduces blocking probability significantly and achieves higher profitability

P5.11 pg. 1148 MULTI-RATE VS. OTN: COMPARING APPROACHES TO BUILD SCALABLE, COST-EFFECTIVE 100GB/S NETWORKS

Marco Bertolini¹, Olivier Rocher², Arnaud Bisson², Pascal Pecci², Giovanni Bellotti¹; ¹Alcatel-Lucent Optics Division Italy, Italy; ²Alcatel-Lucent Optics Division France, France.

In this work we compare network designs based on pure WDM equipments at both 10Gb/s and 100Gb/s line rate, to a pure 100Gb/s design where electrical OTN switches are integrated with WDM equipment. OTN switches introduction grants savings in terms of CAPEX and OPEX, and optimizes network utilization.

P5.12 pg. 1151 UPGRADING OPTICAL NETWORKS WITH ELASTIC TRANSPONDERS Oliver Rival', Annalisa Morea¹, Nicolas Brochier², Hamza

Drid², Esther Le Rouzic²; ¹Alcatel-Lucent Bell Labs, France; ²Orange Labs, France.

We show how rate-adaptive transponders help reduce the cost of optical networks compared to single and mixed-line-rate solutions through a better ability to accommodate growth of traffic and uncertainties in traffic matrices during network upgrades.

P5.13 pg. 1154 EXPERIMENTAL ASSESSMENT OF DYNAMIC INTEGRATED RESTORATION IN GMPLS MULTI-LAYER (MPLS-TP/WSON) NETWORKS Ricardo Martínez¹, Ramon Casellas¹, Raul Muñoz¹;

CTTC, Spain. We present the implementation of the GMPLS control plane functions and path computation algorithm deployed within the ADRENALINE testbed for dynamic integrated restoration in multi-layer networks. The experimental assessment is conducted in terms of blocking probability, path computation time, restorability and the restoration time.

P5.14 pg. 1157 ON THE ENERGY IMPACT OF TRANSMISSION REACH FOR 100G IP-OVER-WDM TRANSLUCENT

REACH FOR 1006 IF-OVER-WDM TRANSLOCENT OPTICAL NETWORKS Giuseppe Rizzelli', Annalisa Morea², Christian Dorize², Oliver Rival², Massimo Tornatore¹; Electronics and Information, Politecnico di Milano, Italy; ²Alcatel-Lucent Bell Labs, France,

We investigate the power consumption of IP-over-WDM networks for 100G coherent systems when varying optical reach values. Benefits of optimal reach depends on the slope of the reach-related consumption function. We also show that "greening" transponders has a linear-like impact on the reduction of network power consumption.

P5.15 pg. 1160 VIRTUALIZATION OVER CONVERGED WIRELESS, OPTICAL AND IT ELEMENTS IN SUPPORT OF RESILIENT CLOUD AND MOBILE CLOUD SERVICES Markos Anastasopoulos¹, Anna Tzanakaki¹, Georgios

Zervas², Bijan Rahimzadeh Rofoee², Reza Nejabati², Dimitra Simeonidou²; ¹Athens Information Technology Greece; ²University of Essex, United Kingdom. This paper studies the interconnection of fixed and mobile users with computing resources through heterogeneous optical/wireless networks. An MILP model for virtualization of physical infrastructures is proposed. The impact of service characteristics on energy consumption and resource requirements is quantified.

P5.16 P5.16 pg. 1163 DESIGN OF SURVIVABLE FLEXIBLE-GRID DWDM

NETWORKS WITH JOINT MINIMIZATION OF TRANSPONDER COST AND SPECTRUM USAGE António Eira^{1,2}, Joao Santos^{1,2}, João Pedro^{1,2}, João Pires²; ¹Nokia Siemens Networks, Portugal; ²Instituto de Telecomunicacoes, Portugal. We present a multi-objective framework to jointly

optimize cost and spectrum in a survivable flexible-grid network with multiple transponder profiles. Through the use of an evolutionary algorithm, the sharing of spectral and interface resources is explored to clearly show the cost/spectrum design trade-off according to different sharing policies

SC6: Access Networks and LAN

P6.01 pg. 1166 PHYSICAL SECURE ENHANCEMENT IN OPTICAL OFDMA-PON BASED ON TWO-DIMENTIONAL SCRAMBI ING

Lijia Zhang^{1,2}, Xiangjun Xin^{1,2}, Bo Liu^{1,2}, Xiaoli Yin¹; ¹School of Electronic Engineering, Beijing University of Posts and Telecommunications, China; ²State Key Laboratory of Information Photonics and Optical Communications, Beijing University of Posts and Telecommunications, China.

This paper proposes a novel physical-enhanced chaotic secure strategy for optical OFDMA-PON based on twodimentinal scrambling. A 15.6-Gb/s encrypted 64QAM-OFDM data has been successfully demonstrated in the experiment

P6.02 P6.02 pg. 1169 INVESTIGATION OF WAVELENGTH CONTROL

INVES IIGATION OF WAVELENGTH CONTROL METHODS FOR NEXT GENERATION PASSIVE OPTICAL ACCESS NETWORKS Stephan Pachnicke', Markus Roppelt', Michael Eisett', Anthony Magee', Peter Turnbull', Jorg-Peter Eibers', 'ADVA AG Optical Networking, Germany', 'ADVA AG Optical Networking Ltd., United Kingdom; 'ADVA AG Optical Networking Carranu. Networking, Germany.

We present a study on wavelength stability require for next generation passive optical network (PON) access systems in the light of induced timing jitter. Based on these findings different realization options of wavelength control methods for use in wavelength tunable PON systems are investigated

P6.03 pg. 1172 ACCURATE RANGING/LOCALIZATION TECHNIQUE

USING RI-UWB FOR SMART FIBER-WIEELESS IN-HOUSE NETWORKS Solomon T. Abortah', Eduward Tangdiongga', Antonino Crivellaro², Roberto Gaudino², Ton Koonen'; '*Electrical* Engineering, COBRA Research Institute, Eindhoven University of Technology, Netherlands; ²Dipartimento di Elettronica, Politecnico di Torino, Italy.

The use of a RoF scheme for localization purposes of mobile stations for in-house networks is presented. Using impulse radio UWB over SMF and time-of-arrival localization method, mobile stations can be localized within centimeters accuracy.

P6.04 pg. 1175 SIGN LABELED OFDM WITH INTENSITY-

MODULATION DIRECT DETECTION IN PON Iván N. Cano¹, Xavier Escayola¹, Victor Polo¹, María C. Santos¹, Josep Prat¹; ¹Signal theory and communications, Universitat Politècnica de Catalunya (UPC), Spain.

A simple technique is presented to improve the sensitivity of cost-effective IMDD-OFDM systems by transmitting the signal absolute value and adding a label with the sample signs. Results indicate that a boost of about 3dB is achieved

P6.05 pg. 1178 FEASIBILITY OF 100G ETHERNET ENABLED BY CARRIERLESS AMPLITUDE/PHASE MODULATION AND OPTICAL OFDM

Jinlong Wei¹, David G. Cunningham², Richard V. Penty¹, Ian H. White¹; 'Electrical Engineering Division, Department of Engineering, University of Cambridge, United Kingdom; ²Avago Technologis, United Kingdom.

For the first time, simulations have analysed the feasibility of 100Gb/s CAP and OFDM systems over SMF Inks using 18.6GHz directly modulated lasers. We have shown that CAP-16/16-QAM-OFDM and CAP-64/64-QAM-OFDM over a single channel can successfully support transmission over 2km SMF, with power dissipation of ~2 times that of a 4×25Gb/s NRZ system

P6.06 pg. 1181 FLEXIBLE MULTI-BAND OFDM RECEIVER BASED ON OPTICAL DOWN-CONVERSION FOR MILLIMETER WAVEBAND WIRELESS BASE STATIONS WAVEDAND WITELESS BASE STATION Paolo Chelfi', Giovanni Serafino', Filippo Scotti', Francesco Laghezza', Antonella Bogoni'; 'National Laboratory of Photonic Networks, CNIT, Italy; ²TECIP, Scuola Superiore Sant'Anna, Italy; 'National Laboratory

of Radar and Surveillance Systems, CNIT, Italy. A novel and flexible photonics-based down-conversion scheme is proposed for wireless receivers in base stations. It allows simultaneous detection of multiple signals at carriers up to tens of GHz, enabling communications at millimeter waves. Experiments demonstrate the effective down-conversion of Wi-Fi signals at 2.4 and 39.8GHz with EVM<-43dB

16:00-17:30 Joint Poster Session—Continued

16:00-17:30

P6.07 pg. 1184 A LIGHTWAVE CENTRALIZED AND DISPERSION IMMUNE BIDIRECTIONAL MM-WAVE OVER FIBER SCHEME FOR ACCESS NETWORKS Bo Yang^{1,2}, Shihuan Zou², Eduward Tangdiongga², Xiaofeng Jin¹, Zizheng Cao², Chigo Okonkwo², Haoshuo Chen², Ton Koonen²; ¹Information Science and Electronic

Engineering, Zhejiang University, China; ²COBRA Research Institute, Eindhoven University of Technology, Netherlands. A lightwave centralized and dispersion immune RoF

A lightwave certrainzed and objectsion infinitum Ror scheme is demonstrated by combining the use of a dual-drive MZM in CO and an AWG in RN. Bidirectional transmission of 25 MS/s 128 QAM signal at 38.4 GHz and 1.25 Gb/s OOK signal with a RSOA is successfully achieved. The proposed scheme also features simple structure and high transmission stability.

P6.08 pg. 1187 EXPERIMENTAL INVESTIGATION OF DISPERSION-INDUCED DISTORTIONS IN IMDD OFDM PON

TRANSMISSIONS Luiz Anet Neto^{1,3}, Didier Erasme², Naveena Genay¹, Luiz Anter Netions, Dudie Erashner, Naveenia Genay, Joffray Guillory, Benoit Charbonnier', Philippe Chanclou', Tuan-Anh Truong', Christelle Aupetit-Berthelemot²; ¹Orange Labs, France; ²GET, Télécom Paris, CNRS LTCI (UMR 5141), France; ³XLM, Université de Limoges, Dpt. C2S2, France.

We experimentally investigate the influence of the intensity modulation index of an OFDM signal submitted to propagation through a dispersive fiber and direct detection at the receiver. We evaluate the role of the parasite phase modulation component created by the laser chirp and its influence on the system's in-band and out-of-band noise.

P6.09 pg. 1190 WAVELENGTH PLAN FOR NEXT-GENERATION HYBRID TDM/VDM PONS Ning Cheng¹, Naresh Chand¹, Frank Effenberger¹; ¹Huawei Technologies USA, USA.

This paper investigates wavelength plans for next generation hybrid TDM/WDM PONs. Simulation results demonstrate that cost effective 10Gb/s directly modulated DFB laser at 1350nm is the best option for TDM/WDM PON downstream with 40km-reach and 1:64-split

P6.10 pg. 1193 DIRECT MODULATION OF A TUNEABLE SLOTTED FABRY-PÉROT LASER WITH ADAPTIVE

SLOTIED FABRY-PEROT LASER WITH ADAPTI MODULATION OFDM Colm Browning', Kai Shi', Prince M. Anandarajah', Richard Phelan², Liam Barry'; ¹The Rince Institute, Dublin City University, Ireland; ²Eblana Photonics, Ireland Ireland.

Next generation optical access networks will require low cost lasers in conjunction with network flexibility and higher data rates. This work presents the direct modulation of a low cost tuneable laser (tuneable over 14nm) with AM-OFDM. Transmission of 10Gb/s over 50km is achieved with these devices.

P6.11 pg. 1196 SYNCHRONIZED SIGNALING DELIVERY FOR VERY HIGH THROUGHPUT 60GHZ IN-BUILDING OPTICAL WIRELESS NETWORK BASED ON DIGITAL OP IICAL WIRELESS NETWORK BASED ON DIGITAL FREQUENCY DIVISION MULTIPLEXING AND DIGITAL NYQUIST SHAPING Zizheng Cao¹, Fan Li⁺, 'Eindhoven University of Technology, Netherlands; ²Hunan University, China.

A simple and low-cost synchronized signaling delivery scheme has been proposed for a 60GHz in-building optical wireless network with 12.7Gbps throughput based on digital frequency division multiplexing and digital Nyquist shaping.

P6.12 pg. 1199 EXPERIMENTAL DEMONSTRATION OF 3 × 10 GBPS RECONFIGURABLE HIGH-SPEED OPTICAL WIRELESS INTERCONNECTS

Ke Wang^{1,2}, Ampalavanapillai Nirmalathas^{1,2}, Christina Lim², Efstratios Skafidas^{1,2}, Kamal Alameh³, ¹National ICT Australia-Victoria Research Laboratory (NICTA-VRL), Australia; 2Department of Electrical and Electronic Engineering, The University of Melbourne, Australia; ³Electron Science Research Institute, Edith Cowan University, Australia.

In this paper we propose and experimentally demonstrate an optical wireless based high-speed reconfigurable card-to-card interconnect architecture The entire transceiver is integrated on a single printed circuit board (PCB) and 3×10Cbps interconnects with reconfigurability are realized for horizontal distances up to 30cm with a BER of ~10-6.

P6.13 pg. 1202 OCTARY QAM AS CAPACITY EXTENSION FOR COHERENT UDWDM PON Bernhard Schrenk', Stefanos Dris', Paraskevas Bakopoulos', Ioannis Lazarou', Karsten Voigt^e, Lars

Zimmermann³, Hercules Avramopoulos¹; ¹School of Electrical & Computer Engineering, National Technical University of Athens, Greece;²Technische Universität Berlin, Germany;³IHP GmbH, Germany.

Optical 8-QAM generation for coherent PONs with a low-complexity and flexible SOA+EAM modulator is experimentally demonstrated. 8-QAM transmission for 3Gb/s per-user bandwidth over 100km and its compatibility with high split and a channel spacing of 3GHz is verified.

P6.14 pg. 1205 DIRECT DPSK MODULATION OF CHIRP MANAGED LASERS FOR SYMMETRICAL 10-GBIT/S WDM-PONS Quang Trung Le¹, Karolina Zogal¹, Tuomo von Lerber¹, Christian Gierl¹, Ali Emsia¹, Dieter Briggmann¹, Franko Kueppers1; 1TU Darmstadt, Germany

In this paper we propose the use of chirp managed In this paper we provide the data of the managed lasers (CML) as cost-effective downstream transmitters in next generation access networks. The network simplicity and an optical power budget of 36 dB obtained with phase-shift-keying direct modulation of CML proves that the proposed solution could be a strong candidate for future WDM-PONs.

P6.15 pg. 1208 REAM INTENSITY MODULATOR-ENABLED COLORLESS TRANSMISSION OF REAL-TIME

OPTICAL OFDM SIGNALS FOR WDM-PONS Jianming Tang'i, Emilio Hugues-salas', Roger P. Giddings', X. Jin', Terry Quinlan', Y. Hong', Stuart Walker'; 'School of Electronic Engineering, Bangor University, United Kingdom; ²School of Computer Science and Electronic Engineering,, University of Essex, United Kingdom.

Reflective electro-absorption modulators are, for the first time, incorporated in real-time optical OFDM (OOFDM) transceivers with online adaptive bit and power loading Colorless OOFDM transmissions of 10.5Gb/s over 25km SSMF in simple IMDD systems are experimentally demonstrated with >5dB improved receiver sensitivities compared to RSOAs.

16:00-17:30 Joint Poster Session—Continued

P6.16 pg. 1211 A HYBRID IN-BUILDING NETWORK ARCHITECTURE INTEGRATING MILLIMETER-WAVE AND WIRED SERVICES

SERVICES Shihuan Zou', Bo Yang'^{1,2}, Eduward Tangdiongga¹, Henrie van den Boom', Ton Koonen'; '*Electrical* Engineering, Eindhoven University of Technology, Netherlands; 'Information Science and Electronic Engineering, Zhejiang University, China.

We demonstrate a hybrid in-building network which is capable of generating and delivering both mm-wave and wired services. A conventional FBG is employed convert the wireless signal to 40 GHz millimeter-wave simultaneously. One of the generated optical harmonics is reused for the uplink transmission

CLEO Focus

P7.01 pg. 1214 NARROW-BAND RADIATION IN THE RANDOM DISTRIBUTED FEEDBACK FIBER LASER Srikanth Sugavanam¹, Nikita Tarasov¹², Dmitry Churkin¹³, Sergei K. Turitsyn¹; 'Aston Institute of Photonic Technologies, Aston University, United Kingdom; ²Novosibirsk State University, Russian Federation; ³Institute of Automation and Electrometry, SB RAS, Russian Federation.

Narrow-band generation is achieved in random distributed feedback (RDFB) fiber laser by using narrow band filters in the center of a distributed cavity. The resulting line-width of -0.1 nm is 10 times less than line-width in classical RDFB laser. Spectral properties can be optimized further.

P7.02 pg. 1217 VECTOR SOLITONS WITH SLOWLY EVOLVING STATES OF POLARISATION Sergey Sergeyev¹, Chengbo Mou¹, Alexey Rozhin¹, Sergei K. Turitsyn¹; ¹Aston Institute of Photonic Technologies, Aston University, United Kingdom. We demonstrate experimentally and study theoretically we denote a scheme scheme and save and scheme scheme new type of stable pulse structures in erbium-doped fibre lasers - polarization evolving vector solitons which evolve in trajectories form a double semi-circle on the Poincaré sphere with characteristic times of 100-1000 round trips.

P7.03 pg. 1220 AMPLIFIER SIMILARITON FIBRE LASER WITH NONLINEAR SPECTRAL COMPRESSION Sonia Boscolo', Sergei K. Turitsyn', Christophe Finot^e; 'Institute of Photonic Technologies, Aston University, United Kingdom; 'Laboratorie Interdisciplinaire Carnot de Bourgogne, UMR 6303, France.

We propose and numerically demonstrate a new concept of fibre laser architecture supporting self-similar pulse evolution in the amplifier and nonlinear pulse spectral compression in the passive fibre. The latter process is beneficial for improving the power efficiency as it prevents strong spectral filtering from being highly . dissipative.

P7.04 pg. 1223 SUB-GEIGER MODE SINGLE-PHOTON DETECTOR USING A LOW-DARK-CURRENT INGAAS

AVALANCHE PHOTODIODE Yoshito Miyamoto¹, Kenji Tsujino², Jun Kataoka¹, Akihisa Tomita³; ¹Research Institute for Science and Engineering, Waseda University, Japan; ²Department of Physics, Tokyo Women's Medical University, Japan; ³Information Science and Technology, Hokkaido University, Japan. We developed a single-photon detector with a dark count rate (DCR) of 5.6 cps with photon detection efficiency operation. Our single-photon detector is comparable in DCR to that of superconducting single-photon detectors.

P7.05 pg. 1226 PLANAR N-FOLD BEAM SPLITTER BASED ON

ADIABATIC LIGHT TRANSFER Charles Ciret', Virginie Coda', Germano Montemezzani', Andon A. Rangelov², Dragomir N. Neshev³; Laboratoire Matériaux Optiques Photonique et Systèmes (LMOPS), University of Lorraine and Supeleo, France; ²Department of physics, Sofia University, Bulgaria; ³Nonlinear Physics Center, Australian National University, Australia.

We demonstrate the adiabatic light transfer from an input waveguide into equal intensity output channels. This concept is using reconfigurable light-induced planar waveguide structure composed of input and buffer waveguides coupled to a waveguide array.

ROOM A

09:00-10:30

Th.1.A • All Optical OFDM (SC3) Chair: Andrew Ellis; University of Cork UCC, Ireland

09:00

Th.1.A.1 • 09:00 **INVIGO** pg. 1229 THEORIES AND APPLICATIONS OF CHROMATIC DISPERSION PENALTY MITIGATION IN ALL OPTICAL OFOM TRANSMISSION SYSTEM Malaz Kserawi', Satoshi Shimizu', Naoya Wada', Ahmed Galib Reza¹, June-Koo Kevin Rhee¹, ¹Dept. of Electrical Engineering, KAIST, Republic of Korea; ²Photonic Network System Laboratory, National Institute of Information and Communications Technology, Japan. Fiber chromatic dispersion in optical OFDM transmission Protection of the second secon

ROOM B

09:00-10:15 Th.1.B • Multimode & MIMO (SC6) Chair: Roberto Gaudino; Politecnico di Torino, Italy

Th.1.B.1 • 09:00 pg. 1244 DEMONSTRATION OF RADIO-OVER-FIBRE TRANSMISSION OF BROADBAND MIMO OVER MULTIMODE FIBRE USING MODE DIVISION

MULTIPLEXING George S. Gordon', Joel Carpenter', Michael J. Crisp', Timothy D. Wilkinson', Richard V. Penty', Ian H. White', Electrical Engineering Division, University of Cambridge, United Kingdom.

A novel method for sending MIMO wireless signals to A nover method noisending winno wireless signals to remote antenna units over a single multimode fibre is proposed. MIMO streams are sent via different fibre modes using mode division multiplexing. Combined channel measurements of 2km MMF and a typical indoor radio environment show in principle a 2x2 MIMO link at carrier frequencies up to 6GHz.

09:15

Th.1.B.2 • 09:15 pg. 1247 INTEGRATED MODE GROUP DIVISION MULTIPLEXER AND DEMULTIPLEXER BASED ON 2-DIMENSIONAL VERTICAL GRATING COUPLERS Hashuo Chen', Ton Koonen', Roy van Uden', Henrie van den Boom', Oded Raz'; 'Dept. of Electrical Engineering COBRA Institute Electro-Optical Communication Systems group (ECO), Eindhoven University of Technology, Netherlands.

Integrated mode group multiplexer and demultiplexer are proposed for Mode Group Division Multiplexing (MGDM). The architecture with optical MIMO demultiplexing and mode-selective spatial filtering is introduced. Simulations show this architecture can successfully track PDM-DQPSK MGDM signals with mode group crosstalk.

Th.1.B.3 • 09:30 Invited pg. 1250 MULTIMODE FIBERS FOR COST-EFFECTIVE HIGH-SPEED, SHORT-RANGE NETWORKS Denis Molin', Marianne Bigot-Astruc', Gerard Kuyt², Gilles Mélin', Pierre Sillard'; '*Prysmian Group, France*; ²Prysmian Group, Netherlands.

This paper reviews the recent progress on the key fails paper reviews the revent progress on the key features of multimode fibers that are the modal bandwidth, the chromatic dispersion compensation and the adaptability to barsh environments through macrobending and radiation resistances.

09:30

Th.1.A.2 • 09:30 pg. 1232 DEMONSTRATION OF 8 X 12.5 GBIT/S ALL-OPTICAL OFOM SYSTEM WITH AN ARRAYED WAVEGUIDE GRATING AND WAVEFORM RESHAPING Satoshi Shimizu', Gabriella Cincotti⁹, Naoya Wada'; 'National Institute of Information and Communications

Technology, Japan; ²Applied Electronics, University Roma Tre, Italy.

We propose and experimentally demonstrate a we projude and experimentary tendnostate a new waveform reshaping technique to restore the orthogonality of the all-optical OFDM subchannels generated by an AWG-based MUX/DEMUX. The proposed scheme effectively restores the orthogonality and drastically improves the BER performance from 10^-4 up to 10^-6.

ROOM D

09:00-10:30

Th.1.D • Nonlinearity Mitigation (SC3) Chair: Seb Savory; University College London, UK

Th.1.D.1 • 09:00 pg. 1256 EXPERIMENTAL DEMONSTRATION OF A FREQUENCY-DOMAIN VOLTERRA SERIES NONLINEAR EQUALIZER IN POLARIZATION-MULTIPLEXED TRANSMISSION

MULIPLEXED IRANSMISSION Fernando P. Guiomar', Jacklyn D. Reis', Andrea Carena², Gabriella Bosco², Armando N. Pinto', Antonio Teixeira^{1,3}, ¹Department of Electronics, Telecommunications and Informatics, University of Aveiro, Instituto de Telecomunicações, Portugal; ²Dipartimento di Elettronica e Telecomunicazioni, Politecrico di Torino, Italy; ³Nokia Siemens Networks Portugal S.A., Portugal.

Experimental demonstration of a dual-polarization Volterra series nonlinear equalizer applied in frequency domain is carried out for 100G polarization-multiplexed QPSK test signals. We were able to reduce the BER by a factor of e-2.5x relatively to the single-polarization approach, with a 1 dB increase in the optimum power.

Th.1.D.2 • 09:15 pg. 1259 NONLINEAR IMPAIRMENT COMPENSATION USING EXPECTATION MAXIMIZATION FOR PDM 16-QAM SYSTEMS

Darko Zibar¹, Ole Winther², Niccolo Franceschi¹, Robert Barkowski¹, Antonio Caballero¹, Valeria Arlunno¹, Mikkel N. Schmidt², Neil G. Gonzales³, Bangning Mao³, Knud J Larsen¹, Ideffonso Tafur Monroy¹; ¹DTU Fotonik, Denmark; ²DTU, DTU Informatics, Denmark; ³ERC Huawei, Germany,

We show experimentally that by using non-linear signal processing based algorithm, expectation maximization, nonlinear system tolerance can be increased by 2 dB. Expectation maximization is also effective in combating I/Q modulator nonlinearities and laser linewidth

Th.1.D.3 • 09:30 pg. 1262 REAL-TIME 112GB/S DWDM COHERENT TRANSMISSION WITH 40% EXTENDED REACH BY TRANSMITTER-SIDE LOW-COMPLEXITY NONLINEAR MITIGATION

Liang Dou', Zhenning Tao', Yuichi Akiyama², Shoichiro Oda², Yangyang Fan', Tomofumi Oyama², Hisao Nakashima², Takeshi Hoshida², Jens C. Rasmussen², ¹Fujitsu Research & Development Center Co.,LTD., China: ²Fuiitsu Limited, Japan: ³Fuiitsu Laboratories Ltd., Japan

One stage nonlinear digital pre-distortion and pulse-carving extend the transmission reach by 40% in real-time DWDM DP-QPSK transmission using digital coherent CMOS LSI. Practical robustness against link uncertainties was confirmed.

ROOM E

09:00-10:15 Th.1.E • Nanophotonics (CLEO Focus)

Chair: Kobus Kuipers; FOM Institue AMOLF, Netherlands

Th.1.E.1 • 09:00 Invited N/A

ULTRAFAST OPTICAL SIGNAL PROCESSING IN SLOW LIGHT PHOTONIC CRYSTAL WAVEGUIDES Thomas Krauss¹; ¹University Of St-Andrews, United Kingdom.

Photonic crystval waveguides operating in the slow Informed by sign waveguides operating in the slow light regime offer a wide range of opportunities for optical signal processing based on the fact that they offer resonant enhancement of light-matter interactic combined with sizeable bandwidth (5-15 nm typ. at 1550 nm) based on the unique ability to engineer their dispersive properties. These opportunities can be categorised along three different lines, namely a) ultracompact optical modulators/switches, b) enhanced nonlinear interaction and c) optical buffers and delays. Regarding modulators, it is now possible to design devices with similar actuation energy/bit as in comparable microrings, yet with 1-2 orders of magnitude larger bandwidth. Regarding nonlinear interaction, we have shown that the efficiency of third harmonic generation and four wave mixing scales as the third or fourth power of the slowdown factor respectively and that surprising conversion efficiencies can be achieved on very short lengthscales. Finally, we highlight recent developments in tunable optical delay, especially the ability to tune the delay at the bit-level and on picosecond timescales

Th.1.E.2 • 09:30 Invited Th.1.E.2 • 09:30 Invited pg. 12+2 ELECTRICALLY-PUMPED PHOTONIC CRYSTAL LASERS FOR OPTICAL COMMUNICATIONS Shinji Matsuo¹, Koji Takeda¹, Tomonari Sato¹, Masaya Notomi², Akihiko Shinya², Kengo Nozaki², Hideaki Taniyama², Koichi Hasebe¹, Takaaki Kakitsuka¹; ¹NTT Photonics Laboratories, Japan; 2NTT Basic Research Laboratories, Japan

We have developed an electrically pumped photoniccrystal laser. Employing an ultracompact embedded active region, the direct modulation is achieved at 10-Gbit/s with ultra-low operating energy. It opens up a novel application area for lasers, namely the optical interconnects for computercom.

ROOM F

09:00-10:30

Th.1.F • Nonlinear Processing I (SC1) Chair: Magnus Karlsson; Chalmers University of Technology, Sweden

Th.1.F.1 • 09:00 pg. 12+9 EXPERIMENTAL CHARACTERIZATION OF A PHASE-SENSITIVE FOUR-MODE FIBER-OPTIC PARAMETRIC AMPLIFIER Thomas Richter², Bill Corcoran¹, Samuel L. Olsson¹, Carl

Indiata Note, join Corolina, Januar L. Januar L. Januar L. Januar L. Januar J. Januar L. Januar J. Januar Heinrich Hertz Institute, Germany.

Four-mode phase-sensitive amplification is rour-induce prizes ensure any initiation is experimentally introduced for the first time. In a proof-of-principle realization using a dual-pump fiber-optic parametric amplifier we achieve nearly 20-dB gain. The influence of the individual phases of the six interacting waves on the signal gain is investigated.

Th.1.F.2 • 09:15 pg. 12, 2 SELF-LINEARIZATION IN ANALOG PARAMETRIC SAMPLING GATE USING HIGHER-ORDER PARAMETRIC MIXING

Bill Ping Piu Kuo¹, Andreas O.J. Wiberg¹, Lan Liu¹, Nikola Alic¹, Stojan Radic¹; ¹University of California, San Diego, USA

We demonstrate a new linearization approach for analog parametric sampling gates. The method utilizes a higher-order parametric mixing product to suppress the quadratic distortion present in the output of a high-power efficiency parametric mixer.

Th.1.F.3 • 09:30 pg. 12, 5 HOMODYNE OPERATION OF A PHASE-ONLY OPTICAL AMPLIFIER

Joseph Kakande¹, Francesca Parmigiani¹, Radan Slavik¹, Periklis Petropoulos¹, David Richardson¹; ¹Optoelectronics Resaerch Centre, United Kingdom. We utilise cascaded four wave mixing to multiply the modulation depth of a phase-only optical signal, and generate a comb of phase locked local oscillators allowing homodyne retrieval of the phase information with enhanced fidelity.

AUDITORIUM

09:00-10:00 Th.1.G • Tutorial Session V (SC5)

Chair: Mario Pickavet; IBBT-Ghent University, Belgium

Th.1.G.1 • 09:00 Tutorial pg. 12-7 ENERGY EFFICIENCY IN CLOUD COMPUTING AND

OPTICAL NETWORKING Rodney S. Tucker¹, Kerry Hinton¹, Rob Ayre¹; ¹University of Melbourne, Australia.

This tutorial provides an overview of some key This tutorial provides an overview of some key parameters that influence energy consumption in cloud computing and optical networking. We present simple energy models of optical and wireless communications networks and cloud computing, and show how energy consumption depends on the underlying equipment, the achievite orbitecture, and the tenffic particid but the the network architecture, and the traffic carried by the entwork. We use these energy models to quantify energy efficiency of the network and identify trends in energy-efficient networking. Finally, we highlight some strategies for improving energy efficiency in future networks, including device design, optical bypass, and optimizing the location of data centres and caches in the network

Rod Tucker is a Laureate Professor at the University of Relourne and Director of the University of Melbourne's Centre for Energy-Efficient Telecommunications (CEET). He is also Director of the Institute for a Broadband-Enabled Society. Rod leads a group of academics and students undertaking research on energy-efficiency in telecommunications. He has previously held positions at Plessey, AT&T Bell Laboratories, Hewlett Packard Laboratories, and Agilent Technologies. In 2009 he served on the Australian Federal Government's Panel of Experts, tasked with providing advice on the establishment of a National Broadband Network in Australia

ROOM A

ROOM B

09:00-10:15

09:00-10:30 Th.1.A • All Optical OFDM (SC3)—Continued Chair: Andrew Ellis; University of Cork UCC, Ireland

09:45 Th.1.A.3 • 09:45 pg. 1235 COMPENSATION OF NONLINEAR CROSS POLARIZATION AND CROSS PHASE MODULATION IN A 112GBI/S 7X4GBAUD PDM COHERENT OFDM CHANNEL CAUSED BY 10GB/S OOK NEIGHBORS Vladimir S. Grigoryan', Michael Y. Frankel'; 'CTO Office, Ciena Corporation, USA.

A method for compensation of both high speed XPoIM and XPM in a 112Gb/s PDM OFDM QPSK channel surrounded by 10Gb/s OOK neighbors is proposed. It allows for more than 4dB Q-factor improvement in a 10x100km NDSF fiber with 90% inline dispersion compensation

10:00 Th.1.A.4 • 10:00 pg. 1238 JOINT DIGITAL SIGNAL PROCESSING FOR SUPERCHANNEL COHEENT OPTICAL SYSTEMS: JOINT CD COMPENSATION FOR JOINT ICI CANCELLATION

CANCELLATION Cheng Liu¹, Jie Pan¹, Thomas Detwiler^{1,2}, Andrew Stark¹, Yu-Ting Hsueh¹, Gee-Kung Chang¹, Stephen E. Ralph¹; ¹Georgia Institute of Technology, USA; ²Adtran Inc., USA. A joint digital signal processing strategy is introduced

A joint utigat signal processing strategy is introduced and demonstrated to improve superchannel system performance over 1280-km SSMF. Joint chromatic dispersion compensation is shown to enable joint inter-channel interference cancellation dramatically reducing spectral generation and detection constraints within unconcented automet superchannel systems.

10:15 Th.1.A.5 • 10:15 pg. 1241 ALL-OPTICAL WAVELENGTH-TIME-SELECTIVE SWITCHING/DROPPING/SWAPPING FOR 100-GHZ-SPACED WDM SIGNALS USING A PERIODICALLY POLED LITHIUM NIOBATE WAVEGUIDE Totab Litrium wirdbaft www.eduibe Jian Wang'', Hongyan Fu', Dongyu Geng', Alan Willner²; ¹Wuhan National Laboratory for Optoelectronics, ¹Wuhan National Laboratory for Optoelectronics, ¹Huazhong University of Science and Technology, China; ²Department of Electrical Engineering, University of Environment of Southern California, USA; ³Communications Technologies Lab, Huawei Technologies Co., Ltd.,, China.

By exploiting sum-frequency generation or cascaded sum- and difference-frequency generation in a periodically poled lithium niobate waveguide, we demonstrate wavelength-/time-selective switching/ dropping/swapping. It is shown these operations are applicable for 100-GHz-spaced WDM signals owing to the narrow-band quasi-phase matching condition. Th.1.B • Multimode & MIMO (SC6)—Continued Chair: Roberto Gaudino; *Politecnico di Torino,* Italy

Th.1.B.4 • 10:00 pg. 1253 FEC-FREE 50 M 1.5 GB/S PLASTIC OPTICAL FIBRE LINK USING CAP MODULATION FOR HOME NETWORKS

Liang Geng¹, Richard V. Penty¹, Ian H. White¹, David G. Cunningham²; ¹University of Cambridge, United Kingdom; ²Avago Technologies, United Kingdom.

LED-based carrierless amplitude and phase modulation is investigated for a multi-gigabit plastic optical fibre link. An FPGA-based 1.5 bit/s error free transmission over 50 m standard SI-POF using CAP64 is achieved, providing 2.9 dB power margin without forward error correction.

10:30-11:00 Coffee Break, Hall 2

ROOM D ROOM E ROOM F 09:00-10:30 09:00-10:15 09:00-10:30 09:00-10:00 Th.1.D • Nonlinearity Mitigation (SC3)-Th.1.F • Nonlinear Processing I (SC1)-

Continued Chair: Seb Savory; University College London, UK

Th.1.D.4 • 09:45 pg. 1265 EXPERIMENTAL DEMONSTRATION OF ELECTRO-OPTICAL MID-SPAN SPECTRUM INVERSION FOR MITIGATION OF NON-LINEAR FIBER EFFECTS Bengt-Erik Olsson¹, Christina Larsson¹, Jonas Martensson², Arne Alping¹; ¹Ericsson AB, Sweden; ²Acreo AB, Sweden.

An opto-electric implementation of an optical spectrum inverter is proposed and experimentally demonstrated in a 561 km transmission link. 3dB increase in span launch a soft with transmission link: soft information and apartadin power was enabled by the inverter for a 112 Gbit's DP-160AM channel and error free operation (BER<10-12) of 10G OOK transmission was obtained with no optical dispersion compensation.

Th.1.D.5 • 10:00 Invited pg. 1268 PROGRESS IN DIGITAL BACK PROPAGATION

Bernhard Schmauss^{1,2}, Chien-Yu Lin^{1,2}, Rameez Asif^{1,2}; ¹LHFT, University of Erlangen, Germany;²SAOT, University of Erlangen, Germany.

Digital backward propagation (DBP) as a method to compensate signal distortions caused by group velocity dispersion and Kerr nonlinearity attracts much attention. As an inverted propagation simulation of the received signal is the key element of DBP, the main challenges is to reduce the computational effort. We review methods developed so far.

Th.1.E • Nanophotonics (CLEO FOcus)-Continued Chair: Kobus Kuipers; FOM Institue AMOLF,

Netherlands

Th.1.E.3 • 10:00 pg. 1276 FIRST EXPERIMENTAL DEMONSTRATION OF A PLASMONIC MMI SWITCH IN 10 GB/S TRUE DATA TRAFFIC CONDITIONS Dimitrios Kalavrouziotis¹, Sotirios Papaioannou^{2,3}

Konstantinos Vyrsokinos³, Laurent Markey⁴, Alain Dereux⁴, Giannis Giannoulis¹, Dimitrios Apostolopoulos¹, Hercules Avramopoulos¹, Nikos Pieros^{2,3}, 'Electrical & Computer Engineering, National Technical University of Athens, Greece; 2 Informatics, Aristotle University of Thessalonki, Greece; ^aInformatics and Telematics Institute, Center of Research and Technology Hellas, Greece; ⁴Institute Carnot de Bourgogne, University of Burgundy, France.

We report the first experimental performance evaluation We report the first experimental performance evaluation of a 75 un long plasmonic MMI switch, hetero-integrated on a SOI platform, operating with 10Gb/s data signals. The switch exhibits 2.9µs response time and 44.5% modulation depth while its exkinction ratio varies from 5.4 to -1.5 dB for 35mW switching power. Error-free performance was achieved.

Continued

Chair: Magnus Karlsson; Chalmers University of Technology, Sweden

Th.1.F.4 • 09:45 pg. 1288 LINEWIDTH PRESERVED BROADBAND PARAMETRIC COMB SEEDED BY TWO INJECTION-

Zhi Tong¹, Andreas O.J. Wiberg¹, Evgeny Myslivets¹, Bill Ping Piu Kuo¹, Nicola Alic¹, Stojan Radic¹, '*Electrical* and Computer Engineering, University of California, San Diego, USA.

By launching two phase-correlated continuous-wave by instruming two preservorrestee commodule-wave pumps via injection-locking, a broadband optical comb generated through higher-order parametric interactions shows unchanged linewidth of each comb line over 100-nm, compared to otherwise quadratically-scaled linewidth

Th.1.F.5 • 10:00 pg. 1291 SELF-PHASE-MODULATION BASED LOW-NOISE, CAVITY-LESS SHORT PULSE SOURCE FOR PHOTONIC-ASSISTED ADC Zhi Tong', Lan Liu', Andreas O.J. Wiberg', Nicola Alic', Stojan Radic'; 'Electrical and Computer Engineering, University of California, San Diego, USA.

We demonstrate a high fidelity picosecond optical pulse source based on a cavity-less architecture. After nonlinear regeneration, low-noise pulse trains leading to 8.0 ENOBs at 3.6-GHz sampling rate was achieved in optical sampling.

Th.1.F.6 • 10:15 pg. 1294 OPTICALLY RESOLUTION ENHANCED ADC WITH DECODING TABLE BASED ON MAXIMUM LIKELIHOOD METHOD Yuji Miyoshi', Shu Namiki², Ken-ichi Kitayama³, Masaharu Ohashi¹; 'Osaka prefecture university, Japan; 'National Institute of Advanced Industrial Science and Technology, Japan; ³Osaka University, Japan;

We demonstrate a real-time optically resolution enhanced ADC system using NOLMs. Taking into account the noise distributions of output signals, we successfully enhanced the ADC resolution and improved the signal to noise and distortion ratio from 16 dB to 23 dB.

10:30-11:00 Coffee Break, Hall 2

AUDITORIUM

Th.1.G • Tutorial Session V (SC5)—Continued Chair: Mario Pickavet; IBBT-Ghent University, Belgium

	ROOM A	ROOM B	ROOM C
	11:00–12:30 Th.2.A • Performance Monitoring and OFDM (SC3) Chair: Hercules Avramopoulos; <i>National TU</i> <i>Athens</i> , Greece	11:00–12:00 Th.2.B • Datacenter (SC6) Chair: Bas Huiszoon; <i>Genexis, Spain</i>	11:00–12:30 Th.2.C • Super Channel Transmission (SC4) Chair: Hiroshi Onaka; <i>Fujitsu, Japan</i>
11:00	Th.2.A.1 • 11:00 pg. 1329 OPTICAL PERFORMANCE MONITORING WITH LOW BANDWIDT COHERENT RECEIVERS Trevor Anderson ^{1,2} , An Tran ¹ , Simin Chen ¹ , Don Hewitt ¹ , Arthur Lowery ³ , Liang Du ² , ¹ VRL, NICTA, Australia; ² Monitoring Division, Australia; ² Electrical Eng., Monash University, Australia. We propose using low bandwidth coherent receivers for distributed optical performance monitoring. We demonstrate OSNR monitoring of a 40-Gbit's polarization multiplexed CO-OFDM signal with a 0.8-GHz receiver using both data aided and blind approaches.	Th.2.B.1 • 11:00 pg. 1347 DEMONSTRATION OF HIGH-SPEED MIMO OFDM FLEXIBLE BADNWIDTH DATA CENTER NETWORK Philip N. Ji', Ting Wang', Dayou Qian', Lei Xu', Yoshiaki Aono ² , Tsutomu Tajima ² , Christoforos Kachris ³ , Konstantinos Kanonakis ¹ , Ioannis Tomkos ² , Tiejun J. Xia ⁴ , Glenn A. Wellbrock'; 'NEC Laboratories Armerica, USA; ² Optical Network Division, NEC Corporation, Japan; ³ Athens Information Technology Center, Greece; ⁴ Verizon, USA. We propose a novel datacenter network architecture utilizing OFDM and parallel signal detection technologies and efficient subcarrier allocation algorithms. Fast, low latency, fine granularity, bandwidth flexible, and low power consumption MIMO switching is demonstrated experimentally.	Th.2.C.1 • 11:00 pg. 1359 1.94TB/S (11×176GB/S) DP.16QAM SUPERCHANNEL TRANSMISSION OVER & 40KM EDFA-ONLY SSMF AND TWO 280GHZ WSSS Jianqiang Li', Magnus Karlsson', Peter A. Andrekson'; 'Department of Microtechnology and Nanoscience, Chaimers University of Technology, Sweden. Using an improved receiver-side spectral shaping technique, we successfully transmitted 1.936 Tb/s (11×176 Gb/s) DP-16QAM superchannel signal over 8×80 km EDFA-only SSMF and two 280 GHz WSSs in support of future 1.6 Tb/s Ethernet with up to 20% FEC overhead.
11:15	Th.2.A.2 • 11:15 pg. 1332 IN-BAND OSNR MONITOR FOR DP-QPSK SIGNAL WITH HIGH-SPEED INTEGRATED STOKES POLARIMETER Takashi Saida', Ikuo Ogawa', Takayuki Mizuno', Kimikazu Sano', Hiroyuki Fukuyama', Yoshifumi Muramoto', Yasuaki Hashizume', Hideyuki Nosaka', Koichi Murata'; ' <i>NTT Photonics Laboratories, NTT Corporation, Japan.</i> We propose an in-band OSNR monitor based on high-speed polarization analysis. We fabricated a high- speed integrated Stokes polarimeter with a PLC-based polarization filter, high-speed photodiodes and trans- impedance amplifiers, and carried out proof-of-concept experiments with 100-Gb/s DP-QPSK signals.	Th.2.B.2 • 11:15 pg. 1350 NETWORK-ON-AND-OFF-CHIP ARCHITECTURE ON DEMAND FOR FLEXIBLE OPTICAL INTRA- DATACENTER NETWORKS Bijan Rahimzadeh Rofoee', Georgios Zervas', Yan Yan', Norberto Amaya', Yixuan Cin', Dimitra Simeonidou'; 'University of Essex, United Kingdom. The paper presents a novel network on-and-off chip approach for highly efficient and transparent intra-datacenter communications. The implemented FPGA-based network on-chip line card enables hitless adaptation between Ethernet and TSON, which is supported by a flexible network off-chip of AoD, demonstrating end-to-end high performance results.	Th.2.C.2 • 11:15 pg. 1362 WDM TRANSMISSION OF 603-GB/S SUPERCHANNELS OVER 845 KM OF 7-CORE FIBER WITH 42.2 B/S/HZ SPECTRAL EFFICIENCY Alan H. Gnauck', Sethumadhavan Chandrasekhar', Xiang Liu', Sebastian Randel', Steve Corteselli', Thierry Taunay', Benyuan Zhu', Mikhail Fishteyn', 'Alcatel- Lucent, Bell Labs, USA; ² OFS Labs, USA. We demonstrate 845-km WDM transmission of eight 100-GHz-spaced 603-Gb/s superchannels in each core of a 76.8-km 7-core fiber placed in a recirculating loop. Space- and polarization-division multiplexing of 16-OAM OFDM signals yields a spectral efficiency of 42.2 b/s/Hz.
11:30	Th.2.A.3 • 11:30 pg. 1335 BLIND CHROMATIC DISPERSION ESTIMATION USING A SPECTRUM OF A MODULUS SQUARED OF THE TRANSMITTED SIGNAL Edem Ibragimov', George Zarris', Sunil Khatana', Lee Dardis', 'Donext Inc., USA. We propose a method for chromatic dispersion estimation without the aid of a training sequence. Experimental data taken on a transmission testbed demonstrates that the high accuracy of this method is not affected by PMD or optical nonlinearity.	Th.2.B.3 • 11:30 pg. 1353 QUAD 14GBPS L-BAND VCSEL-BASED SYSTEM FOR WDM MIGRATION OF 4-LANES 56 GBPS OPTICAL DATA LINKS Jose Estaran', Roberto Rodes', Tien-Thang Pham', Markus Ortsiefer ² , Christian Neumeyr ² , Juergen Rosskopf ^e , Idelfonso Tafur Monroy', ' <i>Technical University</i> of <i>Denmark</i> , (<i>DTU</i>), <i>Denmark</i> , ² VERTILAS GmbH, <i>Germany</i> . We report on migrating multiple lane link into a single WDM L-band VCSEL-based system. Experimental validation successfully achieves 10 km of SMF reach with 4x14Gbps and less than 0.5dB inter-channel crosstalk penalty.	Th.2.C.3 • 11:30 INVIGO pg. 1365 HIGH CAPACITY WDM TRANSMISSION USING TERAIT SUPER-CHANNELS Ilsuro Morita', Wei-Ren Peng'; <i>'KDDI R&D Laboratories, Japan.</i> This paper gives an overview of recent high capacity WDM transmission experiments using superchannels, in which multiple optical carriers are utilized to generate terabit-class channels.

ROOM D ROOM E ROOM F 11:00-12:30 11:00-12:00 11:00-12:15 11:00-12:00 Th.2.D • Few-Mode Fiber Subsystems (SC3)

Chair: Mario Martinelli; Politecnico di Milano, Italy

Th.2.D.1 • 11:00 pg. 1374 SPATIAL-MODE MULTICASTING OF A SINGLE 100-GBITS ORBITAL ANGULAR MOMENTUM (OAM) MODE ONTO MULTIPLE OAM MODES

Van Yan', Yang Yue', Hao Huang', Yongxiong Ren¹, Nisar Ahmed¹, Alan Willner¹, Samuel Dolinar²; ¹University of Southern California, USA; ²Jet Propulsion Lab, USA. A method of spatial mode multicasting in OAM modes spatial division multiplexing is proposed and experimentally demonstrated. By designing the phase pattern of a phase-only spatial light modulator, the input single spatial mode of 100Gbits/s QPSK signal can be multicasted up to 8 spatial OAM modes with crosstalk lower than -20dB.

Th.2.D.2 + 11:15 pg. 1377 EQUALIZATION OF TWO-MODE FIBER BASED MIMO SIGNALS WITH LARGER RECEIVER SETS Xi Chen¹, Ja Ye¹², Yue Sia¹³, An Li¹⁴, Jiayuan He¹, Qian Hu¹, William Shieh^{1,4}, ¹The University of Melbourne, Australia; ²Southwest Jiaotong University, China; ⁴University of Electronic Science and Technology Communication, China; ⁴Centre for Energy- Efficient Telecommunications:

Telecommunications (CEET), Australia. We demonstrate channel equalization of two-mode The demonstrate channel equalization of two-induce fiber based MIMO system using more receivers than transmitters. Specifically, the equalization performances are compared among three methods including zero-forcing (ZF), minimum-mean-square-error (MMSE), and successive-interference-cancellation (SIC)

Th.2.D.3 • 11:30 pg. 1380 2X56-GB/S MODE-DIVISION MULTIPLEXED TRANSMISSION OVER 2KM OF OM2 MULTIMODE FIBRE WITHOUT MIMO EQUALIZATION

Joel Carpenter', Benn Thomsen², Timothy D. Wilkinson'; ¹Department of Electrical Engineering, University of Cambridge, United Kingdom; ²Department of Electronic and Electrical Engineering, University College London, United Kingdom

A Spatial Light Modulator is used to optically demultiplex modal channels on the basis of degenerate propagation constants using a shared phase mask for all channels. This allows groups of modes to be routed to common output fibres eliminating the need for MIMO equalization to transmit 2x56Gb/s QPSK over 2km of OM2 grade 50µm core MMF.

Th.2.E • Frequency Combs (CLEO Focus) Chair: Kobus Kuipers; FOM Institue AMOLF, Netherlands

Th.2.E.1 • 11:00 Invited N/A CHIP SCALE OPTICAL FREQUENCY COMBS Tobias Kippenberg¹; ¹EPFL, Switzerland.

We demonstrate on chip, high repetition rate and low phase noise optical frequency combs using optical micro-resonators. We demonstrate low phase noise behavior in the mid-infrared using ultra high Q MgF2 crystalline resonators as well as low phase noise frequency combs in SiN chip scale resonators and reveal the underlying dynamics

Th.2.F • Nonlinear Processing II (SC1) Chair: Periklis Petropoulos; University of Southampton, UK

Th.2.F.1 • 11:00 pg. 1398 PHASE-SENSITIVE AMPLIFIED OPTICAL LINK OPERATING IN THE NONLINEAR TRANSMIS REGIME SION

REGIME Samuel L. Olsson¹, Bill Corcoran¹, Carl Lundström¹, Martin Sjödin¹, Magnus Karlsson¹, Peter A. Andrekson¹; Photonics Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology, Sweden.

We characterize a phase-sensitive amplifier (PSA) after an 80km fiber span, carrying a single DQPSK channel in the nonlinear transmission regime. The system penalty with increasing intra-channel nonlinear distortion is similar for EDFA and PSA based systems, indicating that the PSA sensitivity advantage may remain with nonlinear transmission

Th.2.F.2 • 11:15 pg. 1401 ALL-OPTICAL TUNABLE WAVELENGTH SHIFTING OF A 128-GBIT/S 64-QAM SIGNAL

UP A 122-GBIT/S 64-QAM SIGNAL Alan H. Gnauck'; Eugene Myslivets', Mihaela Dinu', Bill Ping Piu Kuo², Peter Winzer¹, Robert Jopson', Nicola Alic², Agnieszka Konczykowska³, Filip Jorge³, Jean-Yves Dupuy⁹, Stojan Radic²; Bell Labs, Alcatel-Lucent, USA; ²UCSD, USA; ³III-V Labs, France.

Wavelength shifting of a 21.4-Gbaud 64-QAM signal is Wavelength shifting of a 21.4-cbaud 64-UAM signal is achieved using Bragg scattering with differ-free pumping in a longitudinally stressed highly nonlinear silica fiber. Three wavelengths on a 10-nm tuning range centered on a 24-nm shift are demonstrated with a penalty of less than 2 dB at a BER of 0.001.

Th.2.F.3 • 11:30 pg. 1404 ALL-OPTICAL WAVELENGTH CONVERSION OF A 56 GB/S DQPSK SIGNAL AND ALL-OPTICAL

DEMULTIPLEXING OF A 170 GB/S OOK SIGNAL IN CHALCOGENIDE PHOTONIC CRYSTAL FIBERS CHALCOGENIDE PHOTONIC CRYSTAL FIBERS Sy Dat Le¹², Mathilde Gay¹³, Laurent Bramerie¹², Marcia Costa e Silva¹², Kevin Lengle¹³, Christelle Pareige¹², Thierry Chartier¹², Monique Thual¹², Jean Claude Simon¹², Laurent Brilland¹², David Méchin³, Perrine Toupin²⁴, Johann Troles²⁴, ¹CNRS Foton, France; ²Université européenne de Bretagne, France; ¹PERFOS, R&D platform of Photonics Bretagne, France; ¹CNRS Sciences Chimiques de Rennes, France.

We report on four-wave-mixing based all-optical wavelength conversion of a 56 Gb/s DQPSK signal and all-optical demultiple and of a 170 Gb/s OOK signal in chalcogenide photonic crystal fibers. The high nonlinearity of the fibers allows error free and low power penalty operation with only 60 mW of total average nower

AUDITORIUM

Th.2.G • Tutorial Session VI (SC4) Chair: Huug de Waardt; COBRA TU Eindhoven, The Netherlands

Th.2.G.1 • 11:00 Tutorial pg. 1413 ANALYTICAL MODELING OF NON-LINEAR PROPAGATION IN COHERENT SYSTEMS Pierluigi Poggiolini¹; ¹Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, Italy.

Recently, various analytical models for non-linear propagation in uncompensated coherent systems have been proposed. This tutorial focuses on several related key questions, such as: what are the differences among such models? Can they be unified? Are they accurate? According to models, how does NLI (non-linear interference noise) accumulate over optical bandwidth and distance? How many channels are enough to generate most or all the NLI in a system? What can be done to mitigate, either optically or electronically, the impact of NLI? What is, then, the ultimate fiber capacity? Are there simple design rules which can be derived through the model? What is their impact on the design and management of flexible wavelength-routed networks?

He received his MS and PhD from Politecnico di Torino, Italy. From 1990 to 1995 he was a visiting scholar and a post-doc at Stanford University. He is currently a full professor at Politecnico di Torino. Since 2000 he has been the coordinator of the OptCom group (www.optcom. polito.it). From 2006 to 2010 he was involved in several EU-funded projects; e-Photon/ONe, Nobel II, BONE and Euro-FOS. He served as a member of the Academic Senate of Politecnico di Torino for six years. His current research interests include coherent modulation formats and modeling of non-linear propagation. He is married and is father of two sons and two daughters

Th.2.E.2 • 11:30 pg. 1392 SUPERCONTINUUM FREQUENCY COMB GENERATION IN DISPERSION OSCILLATING OPTICAL FIBER

Alexej Sysoliatin', Mikhail Y. Salganski', Gabriele Manili?, Daniele Modotto², Stefan Wabnitz²; ¹Fiber Optics Research Center, Russian Federation; ²Dept. of Information Engineering, University of Brescia, Italy. We demonstrate that by pumping with a ps pulse a

dispersion oscillating highly nonlinear optical fiber with average normal dispersion, quasi-phase-matched four-wave mixing generates a frequency comb superimposed to a supercontinuum extending over 250 nm and centered at 1550 nm

	ROOM A	ROOM B	ROOM C
	11:00–12:30 Th.2.A • Performance Monitoring and OFDM (SC3)—Continued Chair: Hercules Avramopoulos; <i>National TU</i> <i>Athens, Greece</i>	11:00–12:00 Th.2.B • Datacenter (SC6)—Continued Chair: Bas Huiszoon; <i>Genexis, Spain</i>	11:00–12:30 Th.2.C • Super Channel Transmission (SC4)— Continued Chair: Hiroshi Onaka; <i>Fujitsu, Japan</i>
11:45	Th.2.A.4 • 11:45 pg. 13' 8 EXPERIMENTAL DEMONSTRATION OF PDL PENALTY REDUCTION BY WAVELENGTH- INTERLEAVING TRANSMISSION Kohki Shibahara', Kazushige Yonenaga'; 'Network Innovation Labs., NTT, Japan.	Th.2.B.4 • 11:45 pg. 13) 6 ANALYSIS OF MODE PARTITION NOISE IN MULTI- MODE FIBER LINKS WITH APPLICATION TO 100G ETHERNET Kasyapa Balemarthy ² , Robert Lingle ¹ ; ¹ OFS, USA; ² OFS, India.	
	The validity of wavelength-interleaving (WI) transmission is demonstrated experimentally for reduction of PDL- induced penalty by extreme value statistics. We confirm that WI technique between 2 channels can effectively reduce Q-penalty or outage probability induced by PDL.	We analyze the bit error rate of VCSEL-driven multi- mode fiber links with mode partition noise. We predict a decaying BER even at high SNRs in-contrast to the Ogawa-Agrawal model. This model is pessimistic for 4x25G MMF links with practical VCSELs.	
12:00	Th.2.A.5 • 12:00 pg. 13(1 FIRST EXPERIMENTAL DEMONSTRATION OF REAL.		Th.2.C.4 • 12:00 pg. 13*8

12:0 FIRST EXPERIMENTAL DEMONSTRATION OF REAL-TIME DUAL-BAND OPTICAL OFDM TRANSMISSION AT 17.5GB/S OVER AN EML-BASED 25KM SSMF IMDD SYSTEM USING 4GS/S DAC/ADCS Roger P. Giddings¹, Emilio Hugues-salas¹, Shalva Ben-Ezra², Jianming Tang¹, 'School of Electronic Engineering, Bangor University, United Kingdom; ²Finisar Israel, Israel.

Utilising only 4GS/s DAC/ADCs and without increasing component bandwidths, record-high real-time end-to-end dual-band 17.5Gb/s optical OFDM transmission is experimentally demonstrated over an EML-based 25km SSMF IMDD system. The employed 2GHz baseband and 6±2GHz passband achieve 105b/s and 7.5Gb/s, respectively by adaptive bit/power loading.

Th.2.A.6 • 12:15 pg. 13(4 PER-SYMBOL-BASED DIGITAL BACK-PROPAGATION APPROACH FOR PDM-CO-OFDM TRANSPORT SYSTEMS Wei-Ren Peng¹, Hidenori Takahashi¹, Itsuro Morita¹, Takehiro Tsuritani¹; 1/DDI *R&D Laboratories, Inc, Japan.* 12:15

For PDM-CO-OFDM we propose and experimentally demonstrate a per-symbol-based digital back-propagation method which avoids the use of inefficient overlap-add method, saves one FFT circuit, and exhibits a similar performance when compared with the previous proposal.

12:30-14:00 Lunch, on your own

14:00-15:30 Postdeadline Papers, to be determined

15:30-16:30 Plenary Awards and Closing Ceremony, Auditorium

512-6B/S QUAD-CARRIER PM-QP5K TRANSMISSION OVER 2400-KM SMF-28 SUBJECT TO NARROWING 100-6HZ OPTICAL BANDWIDTH Hung-Chang Chien', Jianjun Yu', Zhensheng Jia', Ze Dong', Xin Xiao'; 'Z'TE USA Inc., USA.

For the first time, a long-reach 400G transmission For the first time, a long-reach 400G transmission proposal based on quad-carrier PM-OPSK with a net spectral efficiency of 4b/s/Hz was experimentally demonstrated. Under the constraint of narrowing 100GHz bandwidth, 512Gb/s quad-carrier PM-OPSK signals were delivered over 2400km SMR-28 with EDFA-only amplification at BER below SD pre-FEC limit.

Th.2.C.5 • 12:15 pg. 13+1 HOW TO USE A LOW-COST DFB LOCAL OSCILLATOR IN ULTRA-LONG-HAUL UNCOMPENSATED COHERENT SYSTEMS Marco Secondini', Gianluca Meloni', Gianluca Berrettini', Luca Polt', Sucula Superiore Sant'Anna, Italy; ²CNIT, Photonic Networks National Laboratory, Italy.

The effectiveness of digital coherence enhancement (DCE) for ultra-long-haul uncompensated coherent (DCE) for ultra-long-hald uncompensated content transmission is experimentally demonstrated. The maximum reach of a 100 Gb/s DP-QPSK system with a low-cost DFB local oscillator is increased from 1600 to 4400 km by DCE, equaling the maximum reach of a narrow-linewidth ECL local oscillator.

ROOM D 11:00-12:30 Th.2.D • Few-Mode Fiber Subsystems (SC3)-

Continue Chair: Mario Martinelli; Politecnico di Milano, Italy

Th.2.D.4 • 11:45 pg. 1383 EXPERIMENTAL DEMONSTRATION OF LDPC CODED FREE-SPACE, SPACE-DIVISION-MULTIPLEXED SYSTEMS USING ORBITAL ANGULAR MOMENTUM MODES

VODES Yongxiong Ren¹, Hao Huang¹, Yequn Zhang², Yang Yue¹, Yan Yan¹, Nisar Ahmed¹, Ivan Djordjevic², Sam Dolina², Alan Willner¹; Department of Electrical Engineering, University of Southern California, USA; ²Department of Electrical and Computer Engineering, University of Arizona, USA; ³Jet Propulsion Lab, USA.

The performance of LDPC coded four-mode multiplexed The performance of LDPC code hour-mode multiplexed Orbital Angular Momentum (OAM) data link using QPSK signal with net data rate of 320Gbit/s is experimentally investigated. The experiment results show that crosstalk effect can be efficiently mitigated and the LDPC codes with soft decoding can provide >7 dB coding depending on OAM crosstalk.

Th.2.D.5 • 12:00 pg. 1386 COMPLEXITY ANALYSIS FOR HIGHER ORDER FEW

MODE FIBER DSP EQUALIZERS Beril Inan¹, Bernhard Spinnler², Filipe Ferreira³, Dirk van den Borne², Susmita Adhikari⁴, Norbert Hanik¹, Sander Jansen2; 1 Technische Universitaet Muenchen, Germany; ²Nokia Siemens Networks, Germany; ³Nokia Siemens Networks, Portugal; ⁴Christian-Albrechts-University, Germany.

In this work, the DSP equalizer complexity is analyzed as a function of the modal dispersion and the number of supported modes of a few-mode fiber. It is shown that a training symbol based scheme such as OFDM is virtually unaffected by the increasing number of modes, whereas for blind FDE/TDE equalization the complexity drastically increases.

Th.2.D.6 • 12:15 pg. 1389 EVALUATION OF PHOTONIC LANTERNS FOR LOSSLESS MODE-MULTIPLEXING

Nicolas K. Fontaine⁺, Roland Ryf⁺, Sergio G. Leon-Saval⁺, Joss Bland-Hawthorn⁺, ¹Alcatel-Lucent Bell Labs, USA⁺, ¹Tnstitute of Photonics and Optical Science (IPOS), The University of Sydney, Australia.

We investigate photonic lanterns for lossless coupling without mode dependent loss between single-mode fibres and a multi-mode fibre supporting up to 15 spatial modes. Measurements of a 7-mode demultiplexer show <1 dB coupling and mode dependent loss.

11:00-12:00 Th.2.E • Frequency Combs (CLEO Focus)-Continued Chair: Kobus Kuipers; FOM Institue AMOLF,

ROOM E

Netherlands

Th.2.E.3 • 11:45 pg. 1395 OBSERVATION OF GIANT DISPERSIVE WAVE EMISSION FROM A DOUBLE-CORE MICROSTRUCTURED FIBER Gabriele Manili¹. Marco Andreana². Alessandro Gauliele Maimi, viana Orinto antaria, Anessanto I Tonello², Vincent Couderc², Daniele Modotto¹, Umberto Minoni¹, Stefan Wabnitz¹; ¹Dipartimento di Ingegneria dell'Informazione, Università di Brescia, Italy; ²XLIM, Université de Limoges, France.

We achieved highly efficient frequency down-conversion Ver advanced inging clinical integration (galaxies) and the output of a double-core microstructured fiber, based on the mechanism of resonant energy transfer from optical solitons into a dispersive wave.

ROOM F

11:00-12:15 Th.2.F • Nonlinear Processing II (SC1)-Continued Chair: Periklis Petropoulos; University of Southampton, UK

Th.2.F.4 • 11:45 pg. 1407 PUMP NOISE CANCELLATION IN PARAMETRIC

WaveLeNGTH CONVERTERS Vahid Ataie¹, Evgeny Myslivets¹, Andreas O.J. Wiberg¹, Nikola Aiic¹, Stojan Radic¹, 'Electrical and Computer Engineering, University of California, San Diego, USA. A new technique for pump-noise transfer cancellation The method relies on simultaneous detection of the pump and idler waveforms and matched digital signal processing. A 4 dB improvement in receiver performance is demonstrated experimentally for the conversion of the conventional 10 Gbps OOK signal.

AUDITORIUM

11:00-12:00 Th.2.G • Tutorial Session VI SC4)—Continued Chair: Huug de Waardt; COBRA TU Eindhoven, The Netherlands

Th.2.F.5 • 12:00 pg. 1410 NONLINEAR PULSE DISTORTION IN FEW-MODE

FIBER Naoise Mac Suibhne^{1,4}, Regan Watts², Stylianos Sygletos^{1,6}, Fatima C, Garcia Gunning^{1,6}, Lars Grüner-Nielsen³, Andrew Ellis^{1,5}; ¹*Tyndall National Institute*, Ineland; "School of Electronic Engineering, Dublin City University, Ireland; "OFS Denmark, Denmark, *Dept. Electronic Engineering, University College Cork, Ireland; *Dept. of Physics, University College Cork, Ireland.

Nonlinear pulse propagation in a few mode fiber is Nonimeral puse propagation in a few mode more is experimentally investigated, by measuring temporal and phase responses of the output pulses by use of a frequency discriminator technique, showing that self-phase modulation, dispersion and linear mode-coupling are the dominant effects.

12:30-14:00 Lunch, on your own

14:00–15:30 Postdeadline Papers, to be determined

15:30–16:30 Plenary Awards and Closing Ceremony, Auditorium