2015 IEEE Optical Interconnects Conference

(OI 2015)

San Diego, California, USA
20-22 April 2015

IEEE Catalog Number: CFP15HSD-POD
ISBN: 978-1-4799-8180-9

Final Program

Monday, 20 April 2015
All Sessions are in Pacific A

8:00 AM - 8:30 AM Breakfast/Coffee Break: Pacific B- Sponsored by TE Connectivity

8:30 AM - 9:00 AM Opening Remarks

9:00 AM - 9:45 AM
Session MA: Plenary I
Session Chair: Azita Emami, California Institute of Technology, USA

MA1 9:00 AM - 9:45 AM (Plenary)

TBD, A. Alduino, *Intel Corporation, CA, USA*....**N/A**

9:45 AM - 10:15 AM Exhibits/ Coffee Break: Pacific B

10:15 AM - 12:15 PM
Session MB: Interconnect Applications
Session Chair: Xuezhe Zheng, Oracle, USA

MB1 10:15 AM - 10:45 AM (Invited)

Efficient Optical Interconnect Architecture for HPC and Data Center Systems, H. Schwetman, *Oracle Labs, USA*

Modern large-scale systems require interconnection networks that are both high-performance and energy efficient. This talk will present a systems approach to developing such a network based on optical intra-node and inter-node communications....**2**

MB2 10:45 AM - 11:00 AM

Performance Analysis and Layout Design of Optical Blades for HPCs Using the OptoBoard-Sim Simulator, A. Siokis, *Computer Engineering and Informatics Dept., University of Patras, Patras, Greece*, P. Maniotis, *Department of Informatics, Aristotle University of Thessaloniki, Thessaloniki, Greece*, E. Varvarigos, K. Christodoulopoulos, *Computer Engineering and Informatics Dept., University of Patras, Patras, Greece*, N. Pleros and S. Markou, *Department of Informatics, Aristotle University of Thessaloniki, Thessaloniki, Greece*

We demonstrate the Optical Board Simulator platform for optical PCB layout design and performance evaluation. Performance of two optical Blades is compared to CRAY-XK7 Blade for the FFTW benchmark, revealing significant throughput and latency improvements....**4**

MB3 11:00 AM - 11:15 AM

Flexible-Bandwidth Power-Aware Optical Interconnects with Source Synchronous Technique, R. Proietti, C. J. Nitta, Z. Cao, M. Clements, G. Tzimpragos and S. Yoo*, Department of Electrical Engineering, University of California, Davis, CA,USA*

This paper investigates energy savings in data centers with flexible-bandwidth poweraware source-synchronous optical interconnects. Network simulations show = 5× energy savings. Link experiment shows error-free operation from 625 Mb/s to 10 Gb/s....**6**

MB4 11:15 AM - 11:30 AM

A Software-Defined Optical Gateway for Converged Inter/Intra Data Center Networks, P. Samadi, H. Guan, K. Wen and K. Bergman*, Columbia University, New York, NY, USA*

We present a software-defined optical gateway for converged inter/intra data center networks. The optical gateway enables transparent rack-to-rack connectivity across data centers through WDM channels. Sub-second reconfiguration time and wavelength defragmentation are experimentally demonstrated....**8**

MB5 11:30 AM - 12:00 PM (Invited)

Limitations and Future Directions for High-Speed Electrical Links, T. Toifl*, IBM Research GmbH, Rueschlikon, Switzerland*

As data rates increase beyond 30Gb/s, electrical links are approaching the limits of both the channel and the technology. In this talk we discuss circuit and system techniques to approach these limits in low- power analog transceiver designs as well as future ADC-based digital I/O designs....**N/A**

MB6 12:00 PM - 12:15 PM

A 25Gbps 3D-Integrated CMOS/Silicon Photonic Optical Receiver with -15dBm Sensitivity and 0.17pJ/Bit Energy Efficiency, S. Saeedi*, California Institute of Technology, Pasadena, CA, USA*, S. Menezo*, CEA-Leti, Grenoble, France* and A. Emami*, California Institute of Technology, Pasadena, CA, USA*

A 3D-integrated CMOS/Silicon photonics optical receiver is presented. At 25Gb/s it achieves -15dBm of sensitivity and 170fJ/bit of energy efficiency. The copper pillar based 3D integration enables low parasitic capacitance and 40µm pitch for interconnection....**11**

12:15 PM - 1:30 PM Lunch (On Own)

1:30 PM - 3:30 PM
Session MC: Transceivers
Session Chair: TBD

MC1 1:30 PM - 2:00 PM (Invited)

100GbE, 400GbE, VCSELs VS. Si Photonics, C. Cole, *Finisar, USA*....**N/A**

MC2 2:00 PM - 2:15 PM

100-Gb/s PAM4 Link Modeling Incorporating MPI, P. V. Mena, E. Ghillino, *Synopsys, Inc., Ossining, NY, USA*, A. Ghiasi, *Ghiasi Quantum LLC, Cupertino, CA, USA*, B. Welch, *Luxtera, Inc., Carlsbad, CA, USA*, M. S. Khaliq, *DET - Politecnico di Torino, Torino, Italy* and D. Richards, *College of Staten Island, CUNY, Staten Island, NY, USA*

100-Gb/s PAM4 optical links based on cascaded silicon modulators and DSP-based receivers are comprehensively modeled. Simulation results highlight the impact of key impairments such as MPI, RIN, passive loss, and receiver noise....**14**

MC3 2:15 PM - 2:30 PM

A Monolithic 56 Gb/s CMOS Integrated Nanophotonic PAM-4 Transmitter, C. Xiong, D. Gill, J. Proesel, J. Orcutt, W. Haensch and W. M. Green, *IBM T.J. Watson Research Center, Yorktown Heights, USA*

We report a demonstration of four-level pulse amplitude modulation (PAM-4) using a segmented traveling-wave silicon photonic Mach-Zehnder modulator with monolithically integrated CMOS drivers. The PAM-4 transmitter shows clear eye openings up to 28 Gbaud....**16**

MC4 2:30 PM - 3:00 PM (Invited)

Energy Efficiency of Optoelectronic Interfaces in Scaled FinFET and SOI CMOS Technologies, J. Li, *University of California - San Diego, La Jolla, CA, USA* and J. Buckwalter, *University of California - Santa Barbara, Santa Barbara, CA, USA*

Evolution of CMOS from planar to FinFET devices raises questions about the scaling of energy efficiency. Comparisons of drivers and transimpedance amplifiers identify device characteristics that contribute to energy efficiency in CMOS-based optoelectronic circuits....**18**

MC5 3:00 PM - 3:15 PM

28 Gb/s NRZ-OOK Using 1530-nm VCSEL, Direct Detection and MLSE Receiver for Optical Interconnects, F. Karinou, N. Stojanovic, G. Goeger, C. Xie, *Huawei Technologies Duesseldorf GmbH, Munich, Germany*, M. Ortsiefer, A. Daly, R. Hohenleitner, B. Kögel and C. Neumeyr, *Vertilas GmbH, Munich, Germany*

We demonstrate the transmission of 28 Gb/s NRZ-OOK over DCF-free links up to 10 km using a monolithic VCSEL, direct detection and an MLSE-based receiver for low-cost, short-reach interconnects. DSP complexity is also investigated in terms of performance optimization....**20**

MC6 3:15 PM - 3:30 PM

Ring Versus Bus: A BER Comparison of Photonic Integrated Networks-on-Chip, S. Faralli*, Scuola Superiore Sant'Anna, Pisa, Italy*, F. Gambini, P. Pintus, I. Cerutti and N. Andriolli*, Scuola Superiore Sant'Anna, Pisa, Italy*

Silicon-photonics bus and ring networks-on-chip are evaluated in terms of transfer function and bit error rates at 10Gb/s, demonstrating that the ring architecture can be effectively used with physical layer performance similar to the bus....**22**

3:30 PM - 4:00 PM Exhibits/Coffee Break: Pacific B

4:00 PM – 5:30 PM
Session MD: Chip-to-Chip & Backplane
Session Chair: Ben Lee, IBM, USA

MD1 4:00 PM - 4:30 PM (Invited)

FPGAs with Integrated Photonics, M. Li, J. Long and J. Martinez*, Altera Corporation, USA*

This paper discusses an integrated FPGA with optical I/Os that can overcome reach, density, power, and performance challenges as link speed increases from 10 Gbps to 25 Gbps and beyond....**24**

MD2 4:30 PM - 4:45 PM

Dispersion Studies on Multimode Polymer Spiral Waveguides for Board-Level Optical Interconnects, J. Chen, N. Bamiedakis*, University of Cambridge, Cambridge, UK*, T. J. Edwards, C. T. Brown*, University of St Andrews, St Andrews, UK*, R. V. Penty and I. H. White*, University of Cambridge, Cambridge, UK*

Dispersion studies are conducted on 1m long multimode polymer spiral waveguides with different refractive index profiles. Bandwidth-length products >40GHz×m are obtained from such waveguides under a 50/125 μm MMF, indicating the potential of this technology....**26**

MD3 4:45 PM - 5:00 PM

Ultra Low Crossing Loss Meshed Waveguide Based on Polynorbornene for Backplane Architecture, K. Kitazoe*,* A. Horimoto, K. Moriya, R. Kinoshita, K. Choki, *Sumitomo Bakelite Co., Ltd., Utsunomiya, Japan* and T. Ishigure*, Faculty of Science and Technology, Keio University, Yokohama, Japan*

We fabricate a high density meshed waveguide based on polynorbornene. We confirm that extremely low optical loss is observed in both 90-degree (0.46 dB/500 crosses) and 45-degree (1.32 dB/500 crosses) meshed patterns....**28**

MD4 5:00 PM - 5:15 PM

Full-Duplex Reconfigurable Card-to-Card Optical Interconnects Based on Hybrid Free-Space and Multi-Mode Fiber Propagation, K. Wang, A. Nirmalathas, C. Lim*, The University of Melbourne, Melbourne, Australia*, K. Alameh*, Edith Cowan University, Perth, Australia* and E. Skafidas*, The University of Melbourne, Melbourne, Australia*

In this paper, high-speed full-duplex card-to-card optical interconnects based on hybrid free-space and multi-mode fiber propagation are proposed and experimentally demonstrated. Results show that bit-error-rate<10-9 can be achieved with a transmission power of 2.3 mW....**30**

MD5 5:15 PM - 5:30 PM

170Gb/s FPGA to FPGA Optical Interconnects Using a x12 14Gb/s Onboard Optics, L. Viitas*, Guzik, Palo Alto, CA, USA*, M. Verdiell, K. Burt, D. Langsam and E. Zbinden*, Samtec Optical Group, Santa Clara, CA,USA*

We report on the development of a commercial PCIe card integrating an Altera Stratix FPGA with Samtec's Firefly 12 lane miniature optical engine. We demonstrate error-free 170 Gb/s FPGA to FPGA bi-directional optical links....**32**

5:30 PM - 7:00 PM Welcome Reception: Pacific B – Sponsored by Intel Corporation

Tuesday, 21 April 2015

8:00 AM - 8:30 AM Breakfast/Coffee Break: Pacific B – Sponsored by Oracle

8:30 AM - 9:45 AM
Session TuA: Plenary II - Advanced Optical Devices
Session Chair: Lukas Chrostowski, University of British Columbia, Canada

TuA1 8:30 AM - 9:15 AM (Plenary)

High-Speed and Energy-Efficient Long-Wavelength VCSELs, M. Amann, *Technische Universität München, Germany*

The exponentially-growing demand for communication bandwidth challenges the energy efficiency of directly modulated laser diodes and optical systems on optical-transport and metro networks. Low-cost high-speed data-transmission links can be realized with vertical-cavity surface-emitting lasers (VCSEL) which offer energy and coupling efficiency, small footprint and packaging versatility....**N/A**

TuA2 9:15 AM - 9:30 AM

Low-Voltage Waveguide Ge APD Based High Sensitivity 10Gb/s Si Photonic Receiver, H. Chen, *IMEC, Heverlee, Belgium*, J. Verbist, *Ghent University, Ghent, Belgium*, P. Verheyen, P. De Heyn, G. Lepage, J. De Coster, P. Absil, *IMEC, Leuven, Belgium*, X. Yin, J. Bauwelinck, *Ghent University, Ghent, Belgium*, J. Van Campenhout, *IMEC, Leuven, Belgium* and G. Roelkens, *Ghent University, Ghent, Belgium*

We demonstrate low-voltage Ge waveguide avalanche photodetectors (APDs) with gain-bandwidth product over 100GHz. A 5.8dB avalanche sensitivity improvement (1×10-12 bit error ratio at 10Gb/s) is obtained for the wire-bonded optical receiver at -5.9V APD bias....**N/A**

TuA3 9:30 AM - 9:45 AM

32 GHz Germanium Bipolar Phototransistors on Silicon Photonics, R. Going,C. Keraly, T. Seok, E. Yablonovich and M. C. Wu, *University of California – Berkeley, Berkeley, CA, USA*

We present designs and simulations for a 32 GHz fT 3-terminal germanium bipolar phototransitor for high-sensitivity 10 GB/s receiving. We also experimentally demonstrate a preliminary, non-optimized phototransistor with 14 GHz fT built on silicon photonics....**38**

9:45 AM - 10:15 AM Exhibits/Coffee Break: Pacific B

10:15 AM - 12:15 PM
Session TuB: Silicon Photonics
Session Chair: Qinfen Hao, Huawei, China

TuB1 10:15 AM - 10:45 AM (Invited)

Silicon Photonics for Optical Connectivity: Small Footprint with Large Dimensions, T. Aalto, M. Cherchi, M. Harjanne, S. Ylinen and M. Kapulainen, *VTT, Espoo, Finland*

Silicon photonics enables optical interconnects with high bandwidth, long reach, low power consumption and scalability to very large systems with low-cost. We show that this is also possible with low-loss micron-scale silicon waveguides....**40**

TuB2 10:45 AM - 11:15 AM (Invited)

Hybrid Electro-Optical Solutions for Sensing and High-Speed Connectivity, A. Hajimiri, *Caltech, USA*

Integrated optics can provide low-loss broadband optical delay much more readily than electronics. On the other hand, electronic integrated circuits offer unparalleled levels of signal gain and signal processing on a single die. The hybrid electro-optical solutions benefiting from best of both domains can provide significant improvements overs solutions solely in one domain. In this paper, we present two examples of such hybrid electro-optical solutions....**42**

TuB3 11:15 AM - 11:30 AM

Thermal Stabilization of a Microring Resonator Using Bandgap Temperature Sensor, S. Yang, *Department of Electrical and Computer Engineering University of Delaware, Newark, DE, USA*, X. Zhu, *Columbia University, New York, NY, USA*, Y. Zhang, *Department of Electrical and Computer Engineering University of Delaware, Newark, DE, USA*, Y. Li, *Columbia University, New York, NY, USA*, T. Baehr-Jones, M. Hochberg, *Coriant Advanced Technology Group, New York, NY, USA* and K. Bergman, *Columbia University, New York, NY, USA*

We demonstrate a thermal stabilization method for a microring modulator by measuring the absolute temperature of the ring and surrounding areas using two pairs of matched pn-junctions. Stabilization is accomplished without needing optical power....**44**

TuB4 11:30 AM - 11:45 AM

Efficient Wide Bandwidth Vertical Grating Couplers in a 45 nm Microelectronics CMOS Process, M. Wade, F. Pavanello, R. Kumar, C. Gentry, *University of Colorado Boulder, Boulder, CO, USA*, A. Atabaki, R. Ram, *Massachusetts Institute of Technology, Cambridge, MA, USA*, V. Stojanovic, *University of California, Berkeley, CA, USA* and M. Popovic, *University of Colorado Boulder, Boulder, CO, USA*

We present the design and characterization of highly directional vertical grating couplers achieving -1.2 dB coupling efficiency with 78 nm 1-dB bandwidth realized in a commercially available 45\,nm microelectronics SOI process....**46**

TuB5 11:45 AM - 12:00 PM

Crosstalk Limitations of Microring-Resonator Based WDM Demultiplexers on SOI, H. Jayatilleka, *University of British Columbia, Vancouver, Canada*

We determine the radius that maximizes the channel count for microring WDM demultiplexers. By measuring crosstalk, we show channel spacing requirements and calculate maximum aggregate data rates for microring and second-order microring based WDM links.....**48**

TuB6 12:00 PM - 12:15 PM

Performing Intelligent Power Distribution in a 4x4 Silicon Photonic Switch Fabric, C. P. Chen, *Columbia University, New York, NY, USA*, X. Zhu, *Columbia University, New York City, USA*, Y. Liu, *Coriant Advanced Technology Group, New York City, USA*, Q. Li, J. Chan, *Columbia University, New York City, USA*, T. Baehr-Jones, M. Hochberg, *Coriant Advanced Technology Group, New York City, USA* and K. Bergman, *Columbia University, New York City, USA*

A dynamically-programmable optical-power distribution scheme is proposed for increased reliability and energy efficiency in systems. Precise power allocation and intelligent switch control with 40 Gb/s error-free operation is realized on the 4x4 multi-stage switch fabric....**50**

12:15 PM - 1:30 PM Lunch (On Own)

1:30 PM - 3:30 PM
Session TuP: Poster Session- Sponsored by HP Labs
Session Chair: TBD

TuP1 1:30 PM – 3:30 PM

Monolithic Integration of III-V Devices with Silicon Photonics on a Modified SOI Platform, Y. Huangfu, W. Wei, C. Qiu and Q. Hao*, Huawei Technologies Co. Ltd., Hangzhou, China*

We propose that monolithic integration of defect-free III-V on Si can be achieved with sub-20nm nano-patterned substrate. A novel SOI structure is modified for realizing this integration in low cost and high yield....**62**

TuP2 1:30 PM - 3:30 PM

Continuous Time CMA Equalizer for Low Power Terabit /Second Optical Interconnects, N. Nambath and S. Gupta*, Indian Institute of Technology Bombay, Mumbai, India*

Continuous time CMA equalizer is proposed for analog processing based DP-QPSK receivers. A two tap equalizer designed using 130nm BiCMOS technology occupies 1.4mm×1.3mm area, consumes 2.5W power and corrects up to 240ps/nm chromatic dispersion....**64**

TuP3 1:30 PM - 3:30 PM

An Alternative to M-PAM Transmission System Featuring Improved Receiver Sensitivity for Optical Interconnects, M. A. Elsherif and A. Malekmohammadi*, The University of Nottingham, Selangor, Malaysia*

Two, three, and four-channel Mapping Multiplexing Technique (MMT) is demonstrated to increase the data capacity of multilevel intensity modulated transmission formats to 2, 3 and 4 bits per symbol with substantial reduction in power penalty....**66**

TuP4 1:30 PM - 3:30 PM

Mode Filtering in Periodic Waveguides by Means of Band Gap Engineering, D. Perez Galacho, D. Marris-Morini*, Université Paris-Sud, Orsay, AE, France*, A. Ortega Moñux, J. Wangüemert Perez*, Universidad de Malaga, Malaga, AE, Spain* and L. Vivien*, Université Paris-Sud, Orsay, AE, France*

In this work, we present and analyze the ability of periodic SubWavelength Grating waveguides to act as mode filters. Moreover, we exploit this ability to design a novel kind of Add/Drop Mode Division Multiplexer exhibiting an extinction ratio over 20dB in the whole C-Band....**68**

TuP5 1:30 PM - 3:30 PM

Polarization Insensitive Vertical Coupler for Multi-Layer Silicon Photonic Integrated Circuits, S. Gao, Y. Wang*, National ICT Australia Ltd (NICTA) - Victoria, West Melbourne, Australia*, K. Wang and E. Skafidas*, The University of Melbourne, Parkville, Australia*

In this paper, we propose a polarization insensitive vertical coupler for 3D silicon photonic integration. Results show that the coupling loss is 0.29 dB for the TE mode and 0.2 dB for the TM mode....**70**

TuP6 1:30 PM - 3:30 PM

Enhancing the Depth Notch Using a Rough-Walled SOI Ring Resonator, R. Mansoor*, DMU, Leicester, UK*

Controllable reflectivity resulting from semi-periodic sidewall roughness is used in a single SOI ring resonator to improve the notch depth without increasing filter size by using cascaded RR....**N/A**

TuP7 1:30 PM – 3:30 PM

Radio Transmission and BER Performance of UWB Pulse Generation based on Directly Modulated Semiconductor Laser, M. Malekizandi, Q. T. Le, D. Briggmann, A. Emsia and F. Küppers*, Technische Universitat Darmstadt, Darmstadt, Germany*

Optical UWB pulse generation and wireless propagation through antenna is investigated. Experimental BER results are presented. It is shown due to antenna characteristics monocycle pulse is converted into 3rd-order Gaussian derivative after wireless propagation....**74**

TuP8 1:30 PM - 3:30 PM

Tunable Double Outputs Coupler Based on Mode Selective MMI, W. Jiang and X. Sun*, Southeast University, Nanjing, China*

We demonstrate a tunable double outputs coupler based on the mode selective MMI. The experimental results show the coupler with very low excess loss of < 0.39dB and low crosstalk of less than -22.2dB....**N/A**

TuP9 1:30 PM - 3:30 PM

Broadband and Polarization-Independent Efficient Vertical Optical Coupling with Si Integrated 45 Degree Mirror, A. Noriki, T. Amano*, National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan*, D. Shimura, Y. Onawa, H. Sasaki, K. Yamada, H. Nishi, T. Tsuchizawa, S. Ukita, M. Sasaki*, Photonics Electronics Technology Research Association (PETRA), Tsukuba, Japan* and M. Mori*, National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan*

Efficient vertical optical coupling of a silicon photonics chip was demonstrated with Si integrated 45 degree mirror. Additional coupling loss was around 1.2 dB over broadband wavelength of 1450-1650 nm for TE/TM polarization....**78**

TuP10 1:30 PM - 3:30 PM

Ultra-Broadband and Low-Loss Optical Power Splitter Based on Tapered Silicon Waveguides, Y. Wang, S. Gao, K. Wang and E. Skafidas*, University of Melbourne, Melbourne, Australia*

We propose a broadband and ultralow-loss (EL < 0.1 dB) optical power splitter based on tapered silicon waveguides. Furthermore, a highly reflective loop-mirror (R > 0.99) based on the proposed splitter is also demonstrated....**80**

TuP11 1:30 PM - 3:30 PM

Exploration of Generalized Circuit Switching Optical Network-on-Chip Architecture, L. Zhang*, University of Maryland Eastern Shore, Princess Anne, MD, USA*, M. Yang*, University of Nevada, Las Vegas, NV, USA***,** J. Yu, X. Ma, P. Liu, J. Yang*, Zhejiang University, Hangzhou, China* and Y. Jiang*, University of Nevada, Las Vegas, NV, USA*

In this paper we compared the performance of a generalized circuit-switching ONoC (CSPIN) with other architectures under different benchmarks. Simulation results have demonstrated the promising properties of CSPIN on power consumption and energy delay product....**82**

TuP12 1:30 PM - 3:30 PM

Optimization of Microring-Based Filters for Dense WDM Silicon Photonic Interconnects, M. Bahadori, D. Nikolova, S. Rumley, C. Chen and K. Bergman*, Columbia University, New York, NY, USA*

The article describes an experimentally validated approach for optimizing wavelength-selective microring filters based on optical signals power penalties. The methodology is used to analyze the performance of WDM links for various bit rates and channel-spacing....**84**

TuP13 1:30 PM - 3:30 PM

Fabrication for High-Density Multilayered GI Circular Core Polymer Parallel Optical Waveguides, K. Suzuki and T. Ishigure*, Keio University, Yokohama, Japan*

We fabricate a 12-ch. 2-layer graded-index circular core multimode polymer parallel optical waveguide using the Mosquito method, and demonstrate a high core-position accuracy for high density on-board interconnection....**86**

TuP14 1:30 PM - 3:30 PM

Integration of Traveling Wave Laser Model into an Mixed Electrical/Optical Circuit Simulator, C. Bonfil*, Optiwave Inc., Ottawa, Canada*, T. Smy*, Carleton University, Ottawa, Canada* and P. Weetmen*, Optiwave Inc., Ottawa, Canada*

This paper presents the incorporation of a laser model based on a traveling wave formulation into a opto-electronic circuit simulator. The model will be compared to a rate equation model and a simple circuit simulation incorporating a micro-ring presented....**88**

TuP15 1:30 PM - 3:30 PM

Scaled Out Optically Switched (SOOS) Network Architecture for Web Scale Data Centers, F. D. Menard*, AEPONYX Inc., Repentigny, Canada*

We propose a Scaled out Optically Switched (SOOS) data center network architecture based on 1:48 planar optical switches with a simple and scalable design well suited for handling growth in east-west bandwidth....**90**

TuP16 1:30 PM – 3:30 PM

Low-Loss Si3N4 Wavelength-Striped Multiplexer, M. Hai and O. Liboiron-Ladouceur*, McGill University, Montreal, Canada*

A Si3N4 4-channel wavelength-striped multiplexer is designed for a 160 Gb/s WDM signal (4x40 Gb/s), incorporating delays up to 9.45 m long (48 ns). Bit-error-rate performance of 1x10^-9 is obtained for all four channels.....**92**

TuP17 1:30 PM - 3:30 PM

Automated Characterization of SiP MZI-Based Switches, M. Hai, M. M. Fard, D. An*, McGill University, Montreal, Canada*, F. Gambini, S. Faralli*, Instituto TeCIP, Pisa, Italy*, G. Battista Preve*, Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Pisa, Italy*, G. W. Roberts and O. Liboiron-Ladouceur*, McGill University, Montreal, Canada*

A testing methodology for commercial automated test equipment (ATE) conventionally used for electrical integrated circuits is developed for photonic integrated circuits. The method is assessing by efficiently characterizing a packaged low-port optical switch matrix....**94**

TuP18 1:30 PM - 3:30 PM

OFDM Pilot-Tone Assisted Distributed Control for SDN-Based Elastic Optical Networks, W. Mo and S. Johnson*, University of Arizona, Tucson, AZ, USA*

We demonstrate for the first time an SDN-based OFDM elastic optical network with pilot-tone assisted distributed control. Improvement in spectral efficiency and a fast reconfiguration time of 30ms have been achieved in our experiment....**96**

TuP19 1:30 PM - 3:30 PM

Integrated Tunable Photodetector for Optical Interconnects, K. Komirisetty*,* D. Geddis and N. Greene, *Norfolk State University, Norfolk, VA, USA*

A tunable MSM photodetector using an integrated thin film NiCr microheater has been designed for photonic integrated circuit, optical interconnect, and access network transceivers. The tuning sensitivity of the photodetector is 1.4nm/mW....**N/A**

TuP20 1:30 PM - 3:30 PM

Optical Modulator with an Integrated Loop Mirror, F. Soltani*, McGill University, Montreal, Canada*, M. Menard*, University of Quebec at Montreal, Montreal, Canada* and A. G. Kirk*, McGill University, Montreal, Canada*

An integrated loop-mirror Mach-Zehnder interferometer (MZI) is demonstrated. This device requires half the phase shift for full modulation. Hence it needs a smaller actuation voltage and has a lower power consumption than a regular MZI....**100**

TuP21 1:30 PM - 3:30 PM

Compact Dedicated Instrument for Non-Invasive Light Monitoring in Photonic Circuits, M. Sampietro, M. Carminati, G. Ferrari, P. Ciccarella, F. Morichetti and A. Melloni*, Politecnico di Milano, Milano, Italy*

A low-noise USB-controlled impedance analyzer specifically designed for light monitoring in photonic circuits using contactless waveguide conductance detector (CLIPP) is presented. The on-board microcontroller and auxiliary analog output allow the closed-loop control of photonic components....**102**

TuP22 1:30 PM - 3:30 PM

Electro-Optic Polymer Channel Waveguide Fabrication Using Multiphoton Direct Laser Writing, B. Amirsolaimani*, University of Arizona, Tucson, AZ, USA*, O. D. Herrera, R. Himmelhuber*, Posdoctoral Research Associate, Tucson, AZ, USA*, K. Kieu*, Assistant Professor, Tucson, AZ, USA*, R. A. Norwood and N. Peyghambarian*, Tucson, AZ, USA*

An all-reflective multiphoton microscope has been used for direct laser lithography and photo-bleaching of SEO250 EO polymer using a 1550nm femtosecond laser to fabricate 4μm channel waveguides. Waveguide loss and cladding index change have also been investigated....**104**

TuP23 1:30 PM - 3:30 PM

Interconnecting University Networks Using a Full-Duplex FSO System Using Coherent Detection and Polarization-Division Multiplexing: Design and Simulation, J. Lopez and C. Hidalgo*, CETYS University, Ensenada, Mexico*

We present the design and simulation results of a full-duplex FSO communication link at 800 Mbps with coherent detection and polarization multiplexing In order to use a single optical system in the full-duplex scheme, subsystems of transmitter and receiver in each location was used....**106**

3:30 PM - 4:00 PM Exhibits/Coffee Break: Pacific B

4:00 PM - 5:30 PM
Session TuD: Circuit Integration for Optical Interconnect
Session Chair: Werner Hofmann, Technische Universität Berlin, Germany

TuD1 4:00 PM - 4:30 PM (Invited)

DWDM Silicon Photonic Transceivers for Optical Interconnect, C. Chen, C. Li, *Hewlett-Packard Company, Palo Alto, CA, USA*, R. Bai, *Oregon State University, Corvallis,OR, USA*, K. Yu, *Texas A&M University, College Station, USA*, J. Fedeli, S. Meassoudene, M. Fournier, S. Menezo, *CEA, LETI, Grenoble, France*, P. Chiang, *Oregon State University, Corvallis, OR, USA*, S. Palermo, *Texas A&M University, College Station, USA*, M. Fiorentino and R. Beausoleil, *Hewlett-Packard Company, Palo Alto, CA, USA*

We present energy-efficient microring resonator-based silicon photonic transceivers for DWDM optical interconnect....**52**

TuD2 4:30 PM - 4:45 PM

Polarization-Insensitive 40Gb/s 4-WDM Channels Receiver on SOI Platform, H. Guan, A. Gazman, *Columbia University, New York City, USA*, Y. Ma, *Coriant Advanced Technology Group; University of Delaware, New York City, USA*, Y. Liu, *Coriant Advanced Technology Group, New York City, USA*, Q. Li, *Columbia University, New York City, USA*, R. Ding, *Coriant Advanced Technology Group, New York City, USA*, Y. Li, *University of Delaware, New York City, USA*, X. Zhu, *Columbia University, New York City, USA*, T. Baehr-Jones, M. Hochberg, *Coriant Advanced Technology Group, New York City, USA* and K. Bergman, *Columbia University, New York City, USA*

We demonstrate a polarization-insensitive silicon photonic receiver operating with 4 × 40 Gb/s wavelength channels at 6.5 nm spacing. The integrated receiver is shown to have <1.2 dB polarization dependent loss and no measured polarization-dependent wavelength shift....**54**

TuD3 4:45 PM - 5:00 PM

25-Gbps 5 × 5 mm^2 Chip-Scale Silicon-Photonic Receiver Integrated with 28-nm CMOS Transimpedance Amplifier, D. Okamoto, Y. Suzuki, K. Yashiki, Y. Hagihara, M. Tokushima, J. Fujikata, M. Kurihara, J. Tsuchida, T. Nedachi, J. Inasaka and K. Kurata, *PETRA, Tsukuba, Japan*

We have developed a compact silicon-photonic receiver integrated with a CMOS transimpedance amplifier (TIA) chip and demonstrated 25-Gbps error-free operation. A minimum sensitivity of -9.7 dBm and a consumption power of 2.3 mW/Gbps were obtained....**56**

TuD4 5:00 PM - 5:15 PM

Area-Efficient Offset Compensation and Common-Mode Control Circuit with Switched-Capacitor Technique in an 18 Gbps Optical Receiver in 80 nm CMOS, L. Szilagyi, G. Belfiore, R. Henker and F. Ellinger, *Technische Universität Dresden, Dresden, Germany*

An 18Gbps optical receiver in 80nm CMOS with a limiting amplifier employing offset compensation and common-mode control is implemented. A conventional and a proposed, 40% smaller circuit in switched- capacitor technique are measured and compared....**58**

TuD5 5:15 PM - 5:30 PM

A 30mW/Channel 4x25Gbps Baud-Rate Bang-Bang CDR Using an Integrating Receiver Based Data Sampling, Z. Wang*, Fudan University, Shanghai, China*, R. Bai, H. Li*, Oregon State University, Corvallis, OR, USA*, J. Wang*, Fudan University, Shanghai, China*, N. Qi*, Oregon State University, Corvallis,OR, USA*, Z. Hong*, Fudan University, Shanghai, China* and P. Y. Chiang*, Oregon State University, Corvallis, OR, USA*

We propose a 4x25Gbps baud-rate bang-bang CDR that incorporates an integrating receiver (INT-RX) to achieve data sampling, eliminating the power overhead from 2x-oversampling. Measurement results demonstrate 25Gb/s error-free operation, 30mW/channel (1.2pJ/bit), and 1.15ps-rms recovered clock jitter....**60**

6:00 PM - 7:30 PM Panel Session: Pacific A- Refreshments will be served

Wednesday, 22 April 2015

8:00 AM - 8:30 AM Breakfast/Coffee Break: Pacific B

8:30 AM - 9:45 AM
Session WA: Plenary III / Optoelectronic Interfaces
Session Chair: Dominic Goodwill, Huawei Industries Inc., Canada

WA1 8:30 AM - 9:15 AM (Plenary)

Memory Connectivity Architecture in High Throughput Systems, J. T. Pawlowski, *Micron Technology Inc., USA*

We stand at perhaps the most interesting cross-road in the history of processing systems. Scaling challenges abound. All aspects of data are growing tremendously in any way we can consider: amount to be stored, bandwidth, amount and diversity to be processed....**N/A**

WA2 9:15 AM - 9:30 AM

A TIA for Optical Networks-on-Chip in 65nm CMOS, R. Polster*, CEA Leti, Grenoble, France*, J. Gonzalez-Jimenez*, CEA-Leti, Grenoble, France*, E. Cassan and L. Vivien*, IEF - Université Paris Sud, Orsay, France*

We present a 260µW, 1 kO to 18 kO transimpedance amplifier. We measured high bandwidth up to 17 GHz and demonstrate the functionality as a receiver-front-end optimized for large DC input range multiple-writer single-reader links....**109**

WA3 9:30 AM - 9:45 AM

4 x 30 Gbps 155mW/Channel VCSEL Driver in 65nm CMOS, J. Wang, N. Qi, Z. Wang, Q. Yang, H. Guo*, Fudan University, Shanghai, China, China*, R. Bai*, Oregon State University, Corvallis, OR, USA*, Z. Hong*, Fudan University, Shanghai China, China* and P. Y. Chiang*, Fudan University, Oregon State University, Shanghai, China, China*

We present a 4-channel VCSEL driver that incorporates input CTLE and 1-tap output FFE. Designed in a standard 65nm-CMOS process, 30Gbps operation is achieved with 155mW/channel (77mW/channel for FFE) from a 1.2/3.0V supply....**111**

9:45 AM - 10:15 AM Exhibits/Coffee Break: Pacific B

10:15 AM - 12:15 PM
Session WB: Packaging Solutions for Optical Interconnects
Session Chair: Marco Fiorentine, HP Labs, USA

WB1 10:15 AM - 10:45 AM (Invited)

Packaging Solutions for Optical Interconnects, P. Fortier, N. Boyer, A. Janta-Polczynski, *IBM Bromont, Canada,*Y. Taira, H. Numata, *IBM Research Tokyo, Japan,* T. W. Lichoulas, E. L. Kimbrell, *AFL Telecommunications, USA,* S. Takenobu, *AGC Electronics, Japan,* Y. Thibodeau, *IBM Bromont, Canada,* S. Kamlapurkar, S. Engelmann, T. Barwicz, *IBM T.J. Watson Research Center, USA*

We show novel solutions to interfacing standard-fiber arrays to silicon photonic chips. We demonstrate automated, self-aligned assembly of 12-fiber arrays to photonic chips and automated, self-aligned assembly of compliant polymer interfaces to photonic chips....**N/A**

WB2 10:45 AM - 11:00 AM

A 25-Gbps Operation of Polymer-based Optical and Electrical Hybrid LSI Package Substrate with Optical Card Edge Connector, T. Amano, S. Ukita, Y. Egashira, M. Sasaki, M. Mori and K. Kurata*, PETRA, Tsukuba, Japan*

We propose a polymer-based optical and electrical hybrid LSI package integrated with silicon photonic chips. We fabricated hybrid package substrate with polymer optical waveguide, mirror and optical card edge connector. We realized a 25-Gbps per channel error-free and low jitter transmission at 1.3-μm....**114**

WB3 11:00 AM - 11:15 AM

Ultra-Dense Optical I/O Interface for Silicon Photonic Interconnects, P. Liao*, McGill University and University of Southern California, Los Angeles, CA, USA*, M. Sakib*, Ciena, Ottawa, Canada*, J. Park, M. Wlodawski, V. Kopp, D. Neugroschl*, Chiral Photonics, Inc., Pinebrook, NJ, USA* and O. Liboiron- Ladouceur*, McGill University, Montreal, Canada*

An ultra-dense optical off-chip I/O interface consisting of 61 grating couplers matching the pitch of a commercial two-dimensional fiber array enables tremendous bandwidth density on the order of tens of Tb/s/mm2 towards high throughput Silicon photonics....**116**

WB4 11:15 AM - 11:30 AM

Single-Mode 32-Fiber Connector with GI Fiber Lens Array, H. Arao, O. Shimakawa, N. Matsushita, Y. Mitose, D. Sasaki, M. Ohmura and H. Kohda*, Sumitomo Electric Industries, Ltd., Yokohama, Japan*

A single-mode 32-fiber lensed connector has been developed. Insertion loss of 1.0 dB on average was achieved by MT connector based structure. Return loss of more than 30 dB was achieved by non-coaxial optical design....**118**

WB5 11:30 AM - 11:45 AM

Optical Interconnection Between III-V Chips on Si by Using Photonic Wire Bonding, Z. Gu, T. Amemiya*, Tokyo Institute of Technology, Tokyo, Japan*, A. Ishikawa*, Okayama University, Okayama, Japan*, T. Hiratani, J. Suzuki, N. Nishiyama*, Tokyo Institute of Technology, Tokyo, Japan*, T. Tanaka*, RIKEN, Saitama, Japan* and S. Arai*, Quantum Nanoelectronics Research Center, Tokyo, Japan*

We demonstrated optical interconnection between two III-V LCI components on Si substrate by using three-dimensional polymeric wires and succeeded in realizing 150-μm optical transmission between laser and detector chips with connection loss around 10dB....**120**

WB6 11:45 AM - 12:00 PM

Vertical-Cavity Surface-Emitting Laser Flip-Chip Bonding to Silicon Photonics Chip, Y. Wang*, University of British Columbia, Vancouver, Canada*, S. S. Djordjecvic, J. Yao, J. E. Cunningham, X. Zheng, A. V. Krishnamoorthy*, Oracle, San Diego, CA, USA*, M. Muller, M. Amann*, Walter Schottky Institut, Am Coulombwall, Germany*, R. Bojko*, University of Washington, Seattle, WA, USA*, N. A. Jaeger and L. Chrostowski*, University of British Columbia, Vancouver, Canada*

We demonstrate the integration of vertical-cavity surface-emitting lasers (VCSELs) with silicon photonics chip using flip-chip bonding technique, with bidirectional vertical-coupled grating coupler for light coupling....**122**

WB7 12:00 PM - 12:15 PM

Integration of Membrane-Based DFB Laser and PIN Photodiode on Si Substrate Toward On-Chip Interconnection, D. Inoue, T. Hiratani, T. Tomiyasu, Y. Atsuji, T. Amemiya, N. Nishiyama and S. Arai*, Tokyo Institute of Technology, Meguro-ku, Japan*

Membrane DFB lasers and photodiodes were monolithically integrated on Si substrate. A threshold current of 280 μA was obtained. A photocurrent of 3 μA was obtained for the laser output of 3 μW.....**124**

12:15 PM - 1:30 PM Lunch (On Own)

1:30 PM - 3:30 PM
Session WC: Modulators
Session Chair: Tian Gu, University of Delaware, USA

WC1 1:30 PM - 2:00 PM (Invited)

Silicon Photonic Enabled 400G/1T Short Reach Optical Interconnects for Data Center Applications, D. V. Plant*, McGill University, Montreal, Canada*

We describe recent polarization-division-multiplexed (PDM) intensity modulation/direct-detection (IM/DD) systems enabled by a novel multiple-input and multiple-output DSP operating in the Stokes space to transmit 224 Gb/s signals. Scaling to 400G/1T is reviewed....**126**

WC2 2:00 PM - 2:15 PM

Compact Verilog-A Modeling of Silicon Carrier-Injection Ring Modulators, B. Wang*, Texas A&M University, College Station, TX, USA*, C. Li, C. Chen*, HP Labs, Hewlett-Packard Company, Palo Alto, USA*, K. Yu*, Texas A&M University, College Station, USA*, M. Fiorentino, R. Beausoleil*, HP Labs, Hewlett-Packard Company, Palo Alto, USA* and S. Palermo*, Texas A&M University, College Station, USA*

A Verilog-A carrier-injection ring modulator model accurately captures electrical and optical dynamics. The impact of pre-emphasis pulse duration, pulse depth, and DC bias is demonstrated with excellent matching between simulated and measured 8Gb/s eye diagrams....**128**

WC3 2:15 PM - 2:30 PM

40-Gb/s BPSK Modulation using a Silicon Modulator , Q. Li*, Columbia University, New York, NY, USA*, R. Ding, Y. Liu, T. Baehr-Jones, M. Hochberg*, Coriant Advanced Technology Group, New York, NY, USA* and K. Bergman*, Columbia University, New York, NY, USA*

We demonstrate BPSK modulation using a silicon traveling-wave modulator at a data rate of 40 Gb/s with record 10.5 pJ/bit energy efficiency, and compare its performance with a commercial Lithium Niobate phase modulator.....**130**

WC4 2:30 PM - 2:45 PM

25 Gb/s Data Transmission with a Node-Matched-Diode Silicon Modulator, S. Kupijai, H. Rhee, A. Al-Saadi, M. Henniges, D. Bronzi, D. Selicke, C. Theiss, S. Otte, H. J. Eichler, U. Woggon*, Technische Universität Berlin, Berlin, Germany*, D. Stolarek, H. H. Richter, L. Zimmermann*, IHP Microelectronics, Frankfurt (Oder), Germany*, B. Tillack and S. Meister*, Technische Universität Berlin, Berlin, Germany*

NRZ data transmission of 25 Gb/s is demonstrated using an ultra-small silicon optical modulator based on a node-matched-diode geometry. Data transmission via an exclusively silicon photonics optical transmission line is presented including an integrated Ge-photodetector.....**132**

WC5 2:45 PM - 3:00 PM

Modeling of Self-Heating Effect for Depletion-Type Si Micro-Ring Modulator, Y. Ban, B. Yu, J. Rhim, J. Lee and W. Choi, *Yonsei University, Seoul, Korea*

We present an accurate model for self-heating effect in depletion-type Si micro-ring modulator which describes incident-power dependent transmission and dynamics. Its accuracy is confirmed with measurement. It can be useful for determining optimal modulation conditions....**134**

WC6 3:00 PM - 3:15 PM

Coupled Photonic Crystal Microcavities for Optical Switching Over Wide Spectral Range, X. Zhang, *University of Texas at Austin, Austin, TX, USA*, S. Chakravarty, *Omega Optics, Inc., Austin, TX, USA*, C. Chung, Z. Pan and R. Chen, *University of Texas at Austin, Austin, TX, USA*

A compact thermo-optic switch comprising a 3.78μm-long coupled photonic crystal resonators coupled to a photonic crystal waveguide is demonstrated with 6nm optical bandwidth, 20dB optical extinction ratio, 18.2mW switching power, and 14.8μsec rise time....**136**

WC7 3:15 PM - 3:30 PM

Backside-Gate-Assisted Broadband Modulation on Silicon-Polymer Hybrid Photonic Crystal Waveguide, X. Zhang, *University of Texas at Austin, Austin, TX, USA*, A. Hosseini, H. Subbaraman, *Omega Optics, Inc., Austin, TX, USA*, J. Luo, A. Jen, *University of Washington, Seattle, WA, USA*, C. Chung, H. Yan, Z. Pan, *University of Texas at Austin, Austin, TX, USA*, R. Nelson, *Air Force Research Laboratory at Wright Patterson, Dayton, USA* and R. Chen, *University of Texas at Austin, Austin, TX, USA*

We demonstrate an electro-optic polymer filled slot photonic-crystal waveguide modulator with a record-high effective in-device r33 of 1230pm/V. Assisted by a backside gate-field, 3-dB bandwidth of 15GHz and energy consumption of 94.4fJ/bit are experimentally demonstrated....**138**

3:30 PM - 4:00 PM Exhibits/Coffee Break: Pacific B

4:00 PM - 5:30 PM
Session WD: Advanced Photonics
Session Chair: Anthony Lentine, Sandia National Laboratories, USA

WD1 4:00 PM - 4:30 PM (Invited)

High Channel Count DFB Laser Array with Precise Channel Spacing for Future PICs Based on REC Technique, X. Chen, *College of Engineering and Applied Sciences, Nanjing University, Nanjing, China*

We have demonstrated high channel count DFB semiconductor laser arrays with precise channel spacing based on reconstruction-equivalent-chirp technique, which are aimed for future large-scale photonic integrated circuits....**140**

WD2 4:30 PM - 4:45 PM

12.2% Waveguide-Coupled Wall Plug Efficiency in Single Mode External-Cavity Tunable Si/III-V Hybrid Laser, J. Lee, J. Bovington, I. Shubin, Y. Luo, J. Yao, S. Lin, J. E. Cunningham, K. Raj, A. V. Krishnamoorthy and X. Zheng*, Oracle Systems, CA, USA*

We demonstrate an external-cavity Si/III-V hybrid laser with a waveguide-coupled wall-plug efficiency of 12.2% at room temperature. The laser operates single-mode in C-band with a linewidth of 0.22 pm and is capable of wavelength tuning....**142**

WD3 4:45 PM - 5:00 PM

Multi-Point Electronic Sense & Control System for Scalable Contactless Integrated Photonic Probes, M. Sampietro, M. Carminati, G. Ferrari, P. Ciccarella, F. Morichetti and A. Melloni*, Politecnico di Milano, Milano, AE, Italy*

A 32channel electronic system for non-invasive light monitoring in integrated photonic circuits with contactless waveguide conductance detector (CLIPP) is presented, featuring 10pS resolution to address multipoint tuning and controlling of optical power variations below -30dBm...**144**

WD4 5:00 PM - 5:15 PM

Towards a Centralized Controller for Silicon Photonic MZI-Based Interconnects, F. Lou, M. Moayedi Pour Fard, P. Liao, M. Hai, R. Priti*, McGill University, Montreal, Canada*, Y. Huangfu, C. Qiu, Q. Hao, Z. Wei*, Huawei Technologies Co., Ltd, Hangzhou, China* and O. Liboiron-Ladouceur*, McGill University, Montreal, Canada*

An FPGA-based centralized controller for a low-port 4×4 SiP multi-stage MZI-based switch is experimentally investigated with 10 Gb/s payload data. Packet contention resolutions and scheduling latencies are studied.....**146**

WD5 5:15 PM - 5:30 PM

V-PI Reduction by Using Modulation Index Booster (MiBo) in RF Links, D. Borlaug*, University of California-Los Angeles, Los Angeles, CA, USA*, R. Torun, O. Boyraz*, University of California-Irvine, Irvine, CA, USA* and B. Jalali*, University of California-Los Angeles, Los Angeles, CA, USA*

The spur-free dynamic range (SFDR) of a modulation index booster (MiBo) link is experimentally and numerically demonstrated. 14.2dB RF gain is demonstrated for 5-fold V-pi reduction at 10GHz with an SFDR3 better than 90dB/Hz....**148**

5:30 PM - 5:45 PM Closing Remarks