PhoxTroT

NEWSLETTER

Photonics for High-Performance, Low-Cost & Low-Energy Data Centers,
High Performance Computing Systems: Terabit/s Optical Interconnect Technologies
for On-Board, Board-to-Board, Rack-to-Rack Data Links

Number 3

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Photonics West 2014 - special edition

Dear Readers,

To a successful new year 2014

Welcome to the third edition of the PhoxTroT newsletter!
In 2014 PhoxTroT will again be widely presented on exhibitions and fairs.
Our third newsletter is therefore dedicated to our wide range of activities during the Photonics West 2014. PhoxTroT is presented in several sessions during the Conference in San Francisco.
This newsletter is furthermore introducing one of our researchers, Ronald Broeke and PhoxTroT's presentations and events.

PhoxTroT @ Photonics West

Monday – Wednesday, 3 - 5 February 2014

Conference 8991

SESSION 3: Mon 1:20 pm to 3:00 pm

[8991-10]

A 1.3 tb/s parallel optics VCSEL link, Kobi Hasharoni, Shuki Benjamin, Amir Geron, Stanislav Stepanov, Niv Margalit, Gideon Katz, Michael Mesh, Compass-EOS (Israel)

[8991-11]

Photonic integration enabling new multiplexing concepts in optical board-to-board and rack-to-rack interconnects, Dimitrios Apostolopoulos, Paraskevas Bakopoulos, Dimitrios Kalavrouziotis, Giannis Giannoulis, Giannis Kanakis, Nikos Iliadis, Christos Spatharakis, National Technical Univ. of Athens (Greece); Johan Bauwelinck, Univ. Gent (Belgium); Hercules Avramopoulos, National Technical Univ. of Athens (Greece)

SESSION 6: Tue 1:50 pm to 3:40 pm

[8991-23]

A holistic way towards high-performance, low-energy and low-cost data centers and HPCs: PhoxTroT, Tolga Tekin, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany) and Technische Univ. Berlin (Germany); Nikos Pleros, Ctr. for Research and Technology Hellas (Greece); Dimitrios Apostolopoulos, National Technical Univ. of Athens (Greece).

Session 8: Wed 8:00 am to 10:10 am

[8991-34]

Demonstration of fully-enabled data centre subsystem with embedded optical interconnect", Richard C. Pitwon, Alex Worrall, Kai Wang, Paul Stevens, Alistair A. Miller, Xyratex Technology Ltd. (United Kingdom); Katharine Schmidtke, Finisar Corp. (United States)

[8991-36]

Fabrication of a non-blocking switching matrix in SOI based on the carrier depletion mechanism for optical interconnects, Francisco Lopez Royo, Antoine Brimont, Todora Angelova, Jose A. Ayucar, Laurent Bellieres, Amadeu Griol, Juan Hurtado, Nuria S. Losilla, Javier Marti-Sendra, Univ. Politècnica de València (Spain)

SESSION 9: Wed 10:40 am to 12:10 pm

[8991-37]

Development of electro-optical PCBs with embedded waveguides for data center and high-performance computing applications, Marika P. Immonen, TTM Technologies, Inc. (Finland); Jinhua Wu, Hui Juan Yan, Long Xiu Zhu, Peifeng Chen, Tarja Rapala-Virtanen, TTM Technologies, Inc.(China)

Conference 8990

SESSION 2: Mon 10:30 am to 12:00 pm

[**8990-8]**

Cost-effective single-etched TM-mode SOI grating couplers for broadband perfectly vertical coupling, George Dabos, Aristotle Univ. of Thessaloniki (Greece); Dimitris Kalavrouziotis, National Technical Univ. of Athens (Greece); Nikos Pleros, Aristotle Univ. of Thessaloniki (Greece); Dimitris M. Tsiokos, Aristotle Univ. of Thessaloniki (Greece) and Ctr. for Research and Technology Hellas (Greece)

SESSION 3: Mon 1:00 pm to 3:30 pm

[8990-14]

Fabrication-tolerant optical filters for dense integration on a micron-scale SOI platform, Matteo Cherchi, Sami Ylinen, Mikko Harjanne, Markku Kapulainen, Tapani Vehmas, Timo Aalto, VTT Technical Research Ctr. of Finland (Finland); George T. Kanellos, Ctr. for Research and Technology Hellas (Greece); Dimitris Fitsios, Ctr. for Research and Technology Hellas (Greece) and Aristotle Univ. of Thessaloniki (Greece); Nikos Pleros, Aristotle Univ. of Thessaloniki (Greece)

SESSION 4: Mon 3:50 pm to 6:30 pm

[8990-22]

Dual-facet coupling of SOA array on 4-µm silicon-on-Insulator implementing a hybrid integrated SOA-MZI wavelength converter, Theonitsa Alexoudi, Dimitris Fitsios, Ctr. for Research and Technology Hellas (Greece) and Aristotle Univ. of Thessaloniki (Greece); George T. Kanellos, Ctr. for Research and Technology Hellas (Greece); Nikos Pleros, Ctr. for Research and Technology Hellas (Greece) and Aristotle Univ. of Thessaloniki (Greece); Tolga Tekin, Technische Univ. Berlin (Germany); Matteo Cherchi, Sami Ylinen, Mikko Harjanne, Markku Kapulainen, Timo Aalto, VTT Technical Research Ctr. Of Finland (Finland)

Conference 8982

POSTERS: Wed 6:00 pm to 8:00 pm

[8982-64]

Optical RAM row access using WDM-enabled all-passive row/column decoders, Sotirios Papaioannou, Theonitsa Alexoudi, Ctr. for Research and Technology Hellas (Greece) and Aristotle Univ. of Thessaloniki (Greece); George T. Kanellos, Ctr. for Research and Technology Hellas (Greece); Amalia Miliou, Nikos Pleros, Ctr. for Research and Technology Hellas (Greece) and Aristotle Univ. of Thessaloniki (Greece)

Photonic integration enabling new multiplexing concepts in optical board-to-board and rack-to-rack interconnects

Photonic integration

Optical interconnects started as a niche application, offering a combination of speed and reach unparalleled by their electrical counterparts. The excess cost of optics, rationalized by the alluring performance benefits brought to the overall system, was partly tackled with the use of inexpensive, commodity optical components. Scaling the capacity of parallel optical links has been regularly addressed by either increasing the number of parallel "lanes" or enhancing the line rate at each lane. Fast forward to today and optical interconnects has evolved into a multi-billion market covering a breadth of different applications spanning from High Performance Computing to Data Centers and expanding even to consumer electronics. The phenomenal surge of online data is for the first time pushing "traditional" OI technologies to their speed boundaries. Increasing the number of parallel lanes (and associated I/Os) may be considered in the short-term but cannot cope with the need for higher information density and optimized energy efficiency.

The PhoxTroT project: Terabit/s Optical Interconnect Technologies for On-Board, Board-to-Board and Rack-to-Rack data links

PhoxTroT is a four-year, large-scale research effort, focusing on high-performance, low-energy and cost and small-size optical interconnects across the different hierarchy levels in Data Center and High-Performance Computing Systems: on-board, board-to-board and rack-to-rack. Optics at board- and chip-level have still not convinced about their cost-efficient character, the main

reason for that being the plethora of photonic technology platforms required in the realization of optical links at these communication distance levels. On the other hand, the "one size fits all" does certainly not apply in this short-range datacom area, necessitating the use of a wide technology portfolio for realistic optical interconnection implementations: VCSELs and, in general, III/V materials are mainstream in optical Tx/Rx functions, polymeric or glass material platforms offer the optimal board-level waveguiding characteristics, mirrors and micromechanics apply in the chip-to-board and board-to-board coupling problems, while CMOS electronics remains without doubt the "intelligent" technology layer. The recent revolution of Silicon photonics brings an additional candidate technology into the game, since they have revealed a tremendous potential for CMOS-compatible optical chip-scale circuitry. Reducing the cost when such a variety of technologies is incorporated into the fabrication line is certainly a non-trivial task. Following this rational, PhoxTroT tackles optical interconnects in a holistic way, synergizing the different fabrication platforms in order to deploy the optimal "mix&match" technology and tailor this to each interconnect layer targeting cost efficiency that can only be achieved when all different technology platform requirements are aligned to a well-established process-level framework and only if the proper balance on the use of the different on-board technologies is achieved. Moreover, as commercial datacom environments have only recently started to "absorb" optical interconnect technologies, there is still plenty of room available for defining their photonic interconnect roadmap. This path includes a necessary "experience transfer" through the establishment of Optical Packet Switch Transport and Advanced Modulation Format transmission features as datacom device deployment guidelines. OPST technologies can definitely expedite bandwidth availability and resource/energy consumption optimization, since bandwidth is occupied only for the duration required releasing bandwidth and hardware resources when no traffic exchange is needed. On the same line, Advanced Modulation Formats have shown to provide data-rate enhancements without requiring additional impetus on the bandwidth of optical technologies and, consequently, on their energy consumption envelope. This roadmap takes into account that Active Optical Cables should be replaced by passive fiber ribbons at several stages in the beyond 2020 optical interconnect area, increasing the perspective to avoid o/e/o conversion at specific rack-level routing applications. Moreover, Advanced Modulation formats at inter-rack level will be certainly utilized as a means to increase aggregate rack-to-rack transmission rates without enhanced optical component and device bandwidth requirements. To this end, a specific level of routing procedures performed directly in the optical domain should support multi-Gbaud packet traffic formats.

Within this frame, PhoxTroT intends to deploy technology building block and components complying with OPST and Advanced Modulation Format operational criteria:

- Active Optical Cable technologies involving 16QAM modulation formats towards breaking the 1Tb/s aggregate data-rate capabilities by employing just 40Gb/s optical component technology. This will bring advanced intensity/phase modulation schemes into rack-to-rack communication level.

- Convergence of both OPST and Advanced Modulation Format characteristics in optical PCB- and rack-level router deployments, evaluating the perspectives of PhoxTroT's on-board and board-to-board routing modules towards operation with advanced intensity/phase modulation formats.

PhoxTroT's AOC is designed to will deploy an 8-lane cable with 1.28 Tb/s aggregate rate and lower than 5mW/Gb/sec relying entirely on SOI-based Tx/Rx chips and offering in this way energy reductions close to 60% compared to state-of-the-art AOCs. This scheme will be compatible with existing packaging solutions, so that a 4-lane cable (640Gb/s) with QSFP+ or an extended 12-lane (1.92Tb/s) with CXP form factor can be produced and enter the market. Volume manufacturing processes to be established within PhoxTroT for the SOI-based Tx/Rx chips are expected, according to provisional estimates, to bring the cost of this 16QAM Active Optical Cable Technology down to less than 3$/Gb/sec even for the QSFP+ form factor, leading to a cost reduction of more than 75% compared to conventional QSFP+ modules.

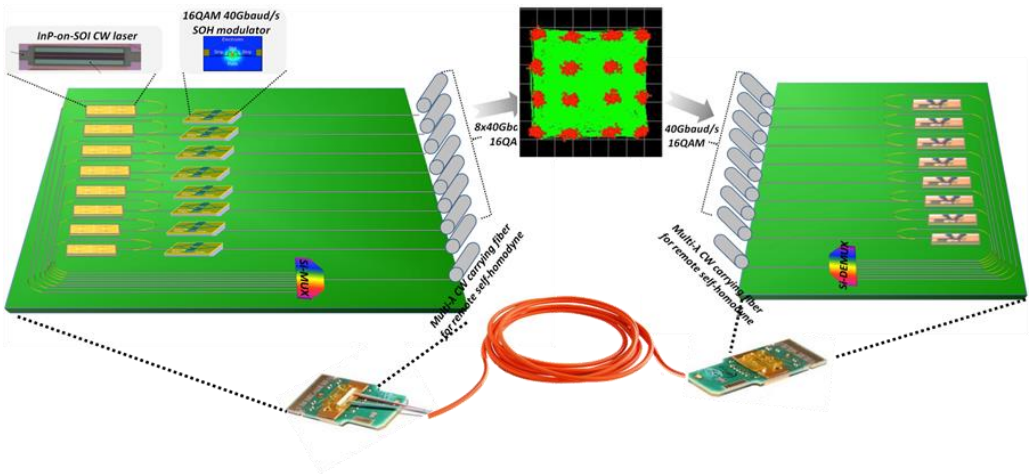

Fig 2: PhoxTroT's Active Optical Cable concept.

One of us

Ronald Broeke

Ronald Broeke received his Ph.D. degree in electrical engineering from the Delft University of Technology in the Netherlands, on the design, fabrication and characterization of optical chips for WDM networks. He continued his research at the University of California at Davis on development of optical systems on chip for applications like optical cdma and arbitrary waveform generation. This was followed by several years at ASML, engaging in hands-on project management and business intelligence systems. He decided to combine his experience in technology and business and founded Bright Photonics B.V. to take part in photonics as the key enabling technology for innovation in this decade. In this light, he is part of the main European projects that lay the foundation for the foundry model for Photonics ICs, such has EuroPIC, and PARADIGM. Last but not least, he is partner with Bright Photonics in PHOXTROT focusing on platform transparent design solutions. Visit us at Holland pavilion - booth #5101.

We look forward to seeing you at SPIE Photonics West 2014

Booth: N° 4601-28 – Part of German Pavillon

February 4 – 6, 2014

Moscone Center in San Francisco, USA

SPIE Photonics West

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