

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

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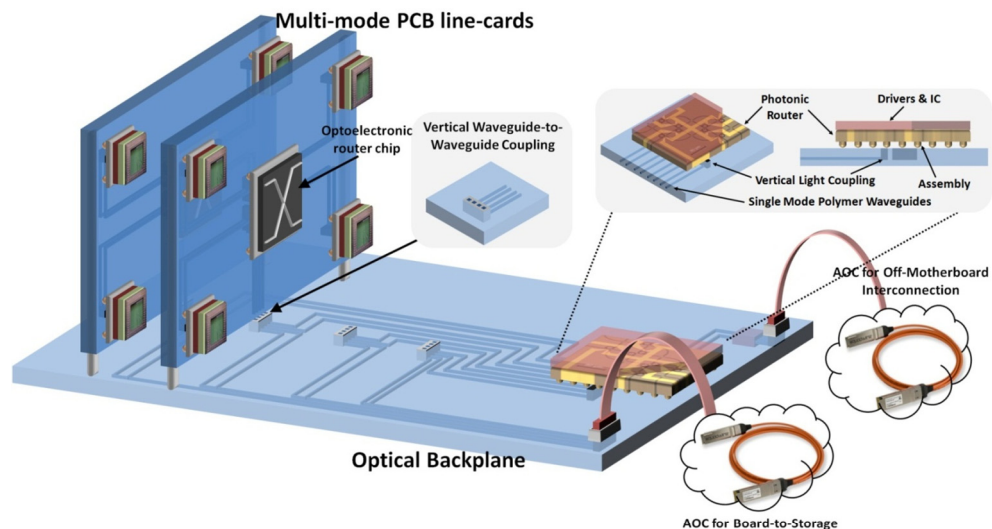
Getting Started

Dear Readers,

Welcome to the first edition of the PhoxTroT newsletter! PhoxTroT is a large-scale European research effort focusing on Photonic Interconnects for Data Centers and HPC Systems.

Each newsletter will highlight recent achievements within the research activities of PhoxTroT, introduce *one of us*, the project members, and give an overview of PhoxTroT presentations at events and of published papers together with a selection of information on PhoxTroT related topics.

PhoxTroT's photonic interconnect platforms: chip-to-chip, board-to-board, rack-to-rack.



Mission of PhoxTroT

PhoxTroT's mission is to streamline the synergistic evolution of the entire technology portfolio towards *cost- and energy-efficient Tb/s-scale chip-to-chip, board-to-board and rack-to-rack* level device development. PhoxTroT aims to generate the necessary energy and cost-efficiency factors through breakthrough component level advances and through mastering the different technology platform design- and process-level requirements into a *coherent methodology* for optochip, optical printed circuit board and active optical cable fabrication.

Objectives of PhoxTroT

The goal of PhoxTroT is to develop new technologies and strategies to make the world's data centers and supercomputers more cost efficient, energy efficient and even more powerful. At least 50% of the energy consumption, as it is today, should be cut. The key to reach that goal is optical data transmission. The main objectives of PhoxTroT include the deployment of:

- Generic building block that can be used for a broad range of applications, *extending performance beyond Tb/s and reducing energy by more than 50%*.
- A unified integration/packaging methodology as a cost/energy-reduction factor for board-adaptable *3D SiP* transceiver and router optochip fabrication.
- The whole "*food-chain*" of low-cost and low-energy interconnect technologies concluding to 3 fully functional prototype systems: an *>1Tb/s throughput* optical printed circuit board and *>50% reduced energy* requirements, a *high-end >2Tb/s throughput* optical backplane for board-to-board interconnection, and a *1.28Tb/s 16QAM* active optical cable that *reduces power* requirements by *>70%*.

Low-cost, low-energy and high performance beyond Tb/s interconnects.

Holistic approach to deploy breakthrough performance and energy metrics for photonic interconnects.

PhoxTroT's specific scientific and technologic objectives are:

- To create the optimal synergies between different technology platforms, streamlining their deployment towards Tb/s-scale, high-performance, low-cost and low-energy optical interconnect components and sub-systems.
- To address optical interconnects in a holistic way and deploy the necessary design- and process-level framework for translating individual interconnect component- and subsystem technology advances into true system-level performance, cost and energy benefits.
- To develop high performance, low-cost and low-energy generic building blocks that can be used for a broad range of applications along all relevant optical interconnect hierarchy layers.
- To deploy a whole new class of high-performance intra-chip optical/electrical TSVs and chip-to-board / board-to-board interfaces.
- To deploy a unified integration/packaging methodology for board-adaptable 3D System-in-Package (SiP) transceiver and router optochip fabrication.
- To establish Optical Packet Switch Transport and Advanced Modulation Format concepts as performance-enhancing and energy-reducing principles in the domain of datacom device technologies.
- To demonstrate the "power" of its technology "food chain" by deploying and experimentally demonstrating three major prototype units with breakthrough performance and energy metrics for on-board, board-to-board and rack-to-rack interconnects
- To bring European research and industry at the fore-front of the optical interconnect field through road mapping, dissemination and training activities, strengthening its collaborative framework with DataCenter and HPC organizations.

PhoxTroT Consortium at Glance

Eighteen European partners from industry and research are committed to the success of the large scale integrating research project PhoxTroT:

Industrial partners

AMO GmbH is among the most active European SMEs on silicon nano-photonics. AMO is acting as silicon nano-photonics foundry, providing SOI waveguide platform for integration of InP-based laser sources, 16QAM modulators and SOH switches.

Austriamicrosystems AG is a global leader in the design and manufacture of high performance integrated circuits. Within the project AMS is developing high-bandwidth TSVs as well as of the 3D integration of the C2B interfaces and optical router.

Bright Photonics is a fables design house for photonic integrated circuits. BP is in charge of the translation of the physical layer models into circuit-level models and generates mask layouts of PhoxTroT building blocks.

Compass Electro Optical Systems Ltd is a developer of high-end routing systems for the carriers and SP market. In the project, CEOS is developing and evaluating the optoelectronic router chip, and chip-to-board, board-to-board and fiber-to-board couplings.

DAS Photonics is a developer of CMOS-compatible integrated photonic components and subsystems for Telecom and Datacom. Within the project DAS is designing and specifying the board-to-board platform and subsystems.

Phoenix BV is a high-tech company developing, supplying and supporting world class software solutions for micro and nano technology corporations and institutes. In PhoxTroT PHX is developing the physical layer Optical Interconnect Software suite.

TTM Technologies / Meadville Aspocomp International Ltd are one of the top five global PCB manufacturers. In PhoxTroT MAIL is in charge of the multi-mode optical polymer PCB design and fabrication, and exploring single mode polymer PCB waveguide platform fabrication and integration of preformed of single mode waveguide layers into PCBs.

Vertilas GmbH is one of the leading global providers in the field of VCSELs. In PhoxTroT, VTL has the task to develop long-wavelength VCSELs arrays.

Xyratex Technology Ltd is one of the world's largest capital equipment suppliers in the area of enterprise data storage systems. XR is active in the end-user requirements, in design and specifications for on-board prototype platform, characterization of optical PCB, and in system testing of the on-board, board-to-board platforms.

Centre for Research and Technology Hellas / Informatics and Telematics Institute is a research organization with significant scientific impact in computer network architectures, optical routing and interconnect platforms. In the project CErTH/ITI builds optical interconnect lab testbed for board-to-board data links, provides system design, simulation analysis and system level evaluation, develops of optoboard simulation engine, and converges OPST and advanced modulation formats in HPC and Data Center architectures.

Centre National de la Recherche Scientifique is the largest research organization in France with high impact research in III-V materials and plasmonic device fabrication. CNRS-UB is focusing on fabrication of plasmonic arc waveguide interfaces and plasmonic vertical vias for optical TSVs, and CNRS-LPN is focusing on design, fabrication and evaluation of the electrical powered III-V/SOI nanolasers.

Computer Technology Institute and Press "Diophantus" is a research organization with top-level expertise on HPC and Data Center network and data transport architectures and protocols. Within PhoxTroT they are designing and evaluating HPC and datacenter architectures supporting OPST and advanced modulation formats, developing optoboard simulation engine.

Institute of Communication and Computer Systems / National Technical University of Athens is one of the largest Greek research institutes with a proven track record in optical communication research in system/component design. In PhoxTroT their tasks are to build an optical interconnect lab-testbed for on-board data links and to contribute in the system-level evaluation of the board-to-board and rack-to-rack platforms and optical packet routing platforms with advanced modulation formatted traffic.

Interuniversitair Micro-Elektronica Centrum is one of the world-leading research-organizations in micro- and nano-electronics. In PhoxTroT IMEC is designing and developing very high speed VCSEL drivers and TIAs.

Karlsruhe Institute of Technology is an institution with a significant record of high impact research advances in photonic integrated components and technologies. Their tasks in PhoxTroT are building a lab-testbed for 16QAM AOC characterization and designing and fabricating silicon-organic hybrid optical modulators for the AOC.

Syddansk Denmark University is a worldwide pioneer in research on plasmonics. SDU is in charge of design and characterization of plasmonic arc waveguide interfaces and plasmonic vertical vias for optical TSVs in PhoxTroT.

Universidad Politecnica de Valencia is participating with NTC that has the most well-known university-owned silicon nano photonics facilities in Europe. UPVLC is responsible for the design and fabrication of carrier depletion type SOI switches as well as for the fabrication of the optical switching matrix.

Fraunhofer Gesellschaft is Europe's largest application-oriented research organization and pioneer in microsystems and reliability, and photonic component integration and fabrication on InP. Fraunhofer HHI is focusing on design and fabrication of surface-illuminated PD arrays, and proving the concept of optical passive circuits using polymers. Fraunhofer IZM is focusing on the 3D SiP integration and WLP packaging and assembly for optical interconnects. In PhoxTroT, IZM is developing vertical interface/via methods and related modeling tools, and providing single mode polymer/glass optical waveguide design and fabrication and their embedding in optical PCB. Fraunhofer IZM is coordinator of PhoxTroT.

One of us :

Sergey I. Bozhevolnyi



Sergey I. Bozhevolnyi received the M.Sc. degree in physics and the Ph.D. degree in quantum electronics from Moscow Institute of Physics and Technology (a.k.a. FizTech), Russia, in 1978 and 1981, respectively, and the Dr.Scient. degree from Århus University, Denmark, in 1998. From 1981 to 1990, he was an Associate Professor with Yaroslavl Technical University, Yaroslavl, Russia. In 1991, he started research on near-field optics at the Institute of Physics, Aalborg University, Denmark, where he has been a Professor since 2003. In 2008, he joined with his group the Department of Technology and Innovation, University of Southern Denmark, Odense. During 2001–2004, he was also the Chief Technical Officer (CTO) of Micro Managed Photons A/S set up to commercialize plasmonic waveguides. In 2007, he was

"Once we accept our limits, we go beyond them."
- Albert Einstein

European leadership and competitiveness beyond 2020.

elevated to the rank of Fellow of the Optical Society of America "For pioneering contributions to near-field optics and plasmonics, including nonlinear phenomena and surface plasmon localization and guiding in nanostructures." He co-authored more than 300 peer-reviewed articles in international journals (h-index = 42) and 10 patents, delivered more than 80 invited talks at international conferences, edited a book "Plasmonic Nano-Guides and Circuits" (Word Scientific, Singapore, 2008). His current research interests include linear and nonlinear nano-optics, surface plasmon polaritons and nano-plasmonic circuits, multiple light scattering, as well as integrated and fiber optics. Other favourite activities, when and if there is a free time, include reading fiction, playing tennis and swimming.

The European Cluster for Optical Interconnects

The European Cluster for Optical Interconnects (ECO Interconnects) is formed to promote visibility, sustainability and exploitation of European R&D efforts in the broad field of Optical Interconnects. Formed by the consortia of optical interconnect related EU funded projects such as Platon, Polysys, Ramplas, Firefly, Mirage, Sepianet and PhoxTroT, and with the participation of industrial and research organizations from all related datacom and telecom fields, the European Cluster for Optical Interconnects initiative aims:

- To collectively promote the commercial exploitation of disruptive photonics technologies and thus drive rapid growth in the EU economy in the emerging field of datacom and computercom
- To foster the collaboration between European projects and strengthen their impact at European and world-wide level
- To foster the collaboration between European industry and EU-funded projects and drive commercial exploitation of disruptive research results and open a route to commercial adoption and market penetration
- To establish synergies and a collaborative framework between other related clusters, ETPs, or other collaborative networks active in the areas of HPC and Data Centers as well as in the areas of photonic technologies.
- To reinforce European industrial leadership & competitiveness beyond 2020
- To coordinate a common effort among European projects to enable broad dissemination

PhoxTroT Presentations & Events

Photonics West 2013: R. Pitwon et al., 'Embedded planar glass waveguide optical interconnect for data centre applications', OPTO Conference.

IEEE CPMT Webinar: R. Pitwon, M. Immonen, 'Electro-optical printed circuit board and interconnect technologies and their application to data center and HPC systems', 13 Feb. 2013.

OIDA Data Center Workshop on Future Needs of "Scale-Out" Data Centers: T. Tekin, 'PhoxTroT - Photonic Interconnects for Data Centers & HPC Systems', 17 March 2013.

IEEE CPMT Webinar: N. Pleros, M. Waldow, 'Active plasmonics co-integrated with Si-photonics and electronics for on-chip interconnects', 11 April 2013.

European Cluster For Optical Interconnects Meeting: PhoxTroT is hosting the first ECO Interconnects Meeting, Hotel Le Plaza, Brussels, 29. April 2013, 17:00-19:00.

DatacenterDynamics CONVERGED: T. Tekin, 'Photonic Interconnects for Data Centers & HPC Systems: The EU FP7 PhoxTroT Approach', Stockholm, 28 May 2013.

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