TERABOARD

www.teraboard.eu

High bandwidth density and scalable optically interconnected Terabit/s Board

H2020-ICT-2015 n°688510

TERABOARD Communication Kit

Deliverable 7.6

Document information

Type of document Deliverable

Lead beneficiary CNIT

Due date (in months) M1

Dissemination level Public

Revision history

Date	Revision	Changes
29/12/2015	0	Initial version

Contributors

Marco Romagnoli (CNIT), Gabriele De Angelis (CNIT), Alexandra Petrochenko (CNIT contractor)

Acknowledgements and Copyright

TERABOARD is an initiative of the Photonics Public Private Partnership, under the grant agreement H2020-ICT-2015 n°688510.

Contents

Abstract

Deliverable 7.6 contains the Narrative Text of the project and the details about the official website www.teraboard.eu.

Narrative Text

A Narrative Text about the project was redacted. It includes all the necessary information, targeting a general audience and a focusing on what TERABOARD will realize in terms of technical achievements as well as economical and societal benefits for the EU.

The official Narrative Text can be downloaded here:

TERABOARD Narrative text – 10/12/2015

The full text of the Narrative Text is reported below:

TERABOARD

High bandwidth density and scalable optically interconnected Terabit/s Board

The European project TERABOARD is an initiative of the Photonics Public Private Partnership, under the grant agreement H2020-ICT-2015 n°688510, with a total budget of 4.25 million EURO. The project will have a total duration of 36 months, starting on December 1st, 2015.

PHOTONICS21 HORIZON 2020

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

www.photonics21.org

TERABOARD gathers the following beneficiaries:

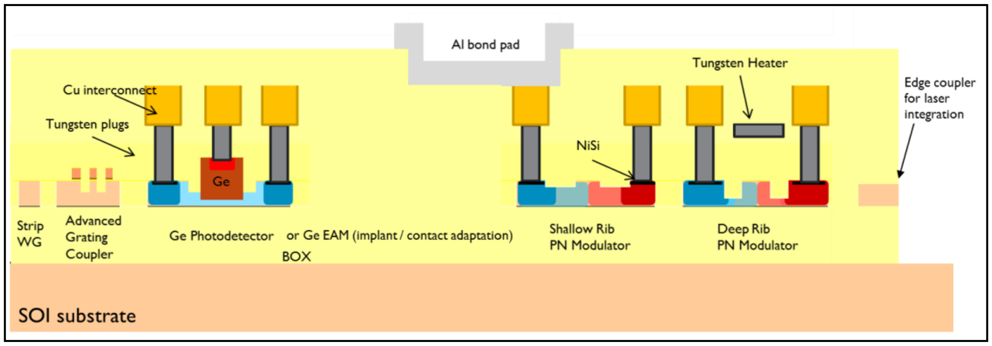
- Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Italy – *Coordinator*
    - INPHOTEC fabrication center at Scuola Superiore Sant'Anna, Italy –*Linked third party*
- Ericsson Telecomunicazioni, Italy
- STMicroelectronics, Italy
- IMEC, Belgium
- Alcatel-Lucent Italia, Italy
- iMinds, Belgium
- Consiglio Nazionale delle Ricerche (CNR), Italy
- Universitat Politecnica De Valencia (UPV), Spain
- European Photonics Industry Consortium (EPIC), France

What is TERABOARD

TERABOARD concerns topics of Optical Communication for Data Centers and Photonic Integrated Circuits (PIC). The basic concept underpinning the TERABOARD proposal consists of demonstrating a scalable, low power, low cost photonic technology to sustain the continuous increase of bandwidth density by leveraging on combination of scalability and low energy consumption. TERABOARD is a complete solution for scalable low-energy optical interconnections to be used in multiple application scenarios, ranging from intra-board through intra-data center communication, such as high-speed switch/router line cards, baseband processing units in 5G radio base stations, and next generation data center multi-server blades. From the system point of view,

TERABOARD is a new technology that enables very large aggregated bandwidth density (Tb/s/cm^2) on board. Thus, the number of operations in a single board are increased, instead of achieving the same number of operations in many boards or in a rack. The most relevant advantage results in avoiding power supplying of multiple boards. The concentration of a large number of operations in a single board leads to a radical system innovation, reduction of total energy cost and reduction of hardware size and cost.

The three large industrial partners (Ericsson, Alcatel-Lucent and STMicroelectronics) are giants in the telecom field and together with IMEC pioneered and are very active in silicon photonics integrated circuits. They not only possess vast experience in breeding innovation and creating market opportunities, but also adopt a strong innovation-driven policy. CNIT is a large organization spanning over the entire spectrum of telecommunications, that recently hired an experienced team in silicon photonics design, fabrication and packaging and that has a long-standing collaboration with the partner Ericsson for R&D in optical communications. CNIT also partners with STMicroelectronics for packaging technologies and pilot lines. Alcatel-Lucent is an industrial leader in optical communications and in TERABOARD offers its knowledge to develop technical solutions for optical interconnections in photonic integrated circuits. These factors, together with the high level competences of iMinds, CNR, UPV and EPIC, will ensure the ability to innovate beyond the research stage.



IMEC silicon photonics technology

Scenario

The exponential growth of traffic demand and its explosion expected for the future mainly driven by smartphones and mobile internet is leading to a significant change in the design of next generation telecom hardware platforms and datacom equipment: the future platforms will have to be much more efficient in terms of energy consumption, footprint and cost, and will need to be architecturally simpler. In data centers, cloud computing has received increasing attention due to its capability to dynamically provide services ranging from computing to networking and to storage, with resources distributed somewhere in the cloud and available on demand and transparent to end users. Fast growing services will require data centers to be significantly more powerful, energy efficient and compact. The challenges for equipment vendors will be to increase the bandwidth density and to decrease the consumption by two orders of magnitude by 2022. Current optical interconnects are used only for inter-board communications, while for the intra-card level the electrical interconnects suffice. This is thanks to the required bandwidth of less than 100 Gb/s/cm^2, the connections length of few centimeters and the data rate within 10 Gb/s. In the long run, however, also chip-to-chip communication inside a card will become optical due to increase in transmission rate up to 25 Gb/s and 50 Gb/s. During this transformation, the integrated technologies needs to evolve from moderate bandwidth-density parallel silicon photonics transceivers to high bandwidth-density 3D optical interposers, tightly integrated with electronic Application-Specific Integrated Circuits (ASIC) inside Optical Multi-Chip Modules (OMCM). The global data center IP traffic will see a 23% cumulative annual growth rate, with a large majority of traffic (around 76%) exchanged within the data center itself, pushing even more communication load on data center servers and switches *[1]*. Regarding chip-to-chip interconnections, it is predicted a tenfold communication requirement increase by 2020 *[2]*, which cannot be adequately satisfied by current standards, e.g. PCI-express. A recently published CIR report investigates the market trend for on-chip and chip-to-chip interconnects, showing great potentials for effective optical solutions, with chip-to-chip interconnection revenues reaching around $775 million by 2020, and on-chip interconnection revenues exceeding $210 million by 2025 *[3]*.

[1] CISCO Systems, "Cisco Global Cloud Index: Forecast and Methodology, 2013–2018," White Paper, 2014.

[2] Y. Arakawa, T. Nakamura, Y. Urino, and T. Fujita, "Silicon Photonics for Next Generation System Integration Platform," IEEE Commun. Mag., vol. 51, no. 3, pp. 72-77, 2013

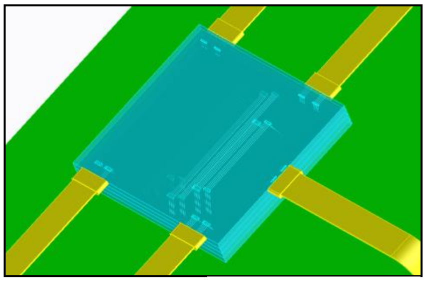
[3] CIR, "Markets for on-chip and chip-to-chip optical interconnects - 2015 to 2024," Report # CIR-OI-MCC-0115, 2015.

Solutions

The innovative solutions proposed by TERABOARD consist of developing advanced intra-board and edge interfaces, with ultra-high density and scalability in bandwidth, low insertion loss and low energy consumption. The target of energy cost per channel is 2.5 pJ/bit, with a manufacturing cost of 0.1 $/Gb/s in volumes. These indicators are 10 times better with respect to the commercial state of the art. The intra-board communication will be a novel concept based on a 3D passive interconnection platform with no intersections and no need of Wavelength Division Multiplexing (WDM). To reduce the overall power consumption of a data center, intra-rack communications will avoid the use of WDM, cutting the fibers cost and the footprint needed by fiber connectors. In both intra-board and intra-rack communications, TERABOARD will demonstrate a 10-times reduction of required power with respect to present commercial solutions.

TERABOARD will develop the following functionalities:

1. A silica-based platform (called Starboard) for inter-node connections with unprecedented bandwidth densities and limitless scalability, very low insertion loss and with possibility of embedded functionalities as filters
2. Intra-board transceiver banks for low power optical interconnection over short distances (40 cm), with aggregate bandwidth of 0.7 Tb/s/node (25 Gb/s x 28 waveguides), consumption of 2.5 pJ/bit and bandwidth density greater than 15 Tb/s/cm^2



Starboard

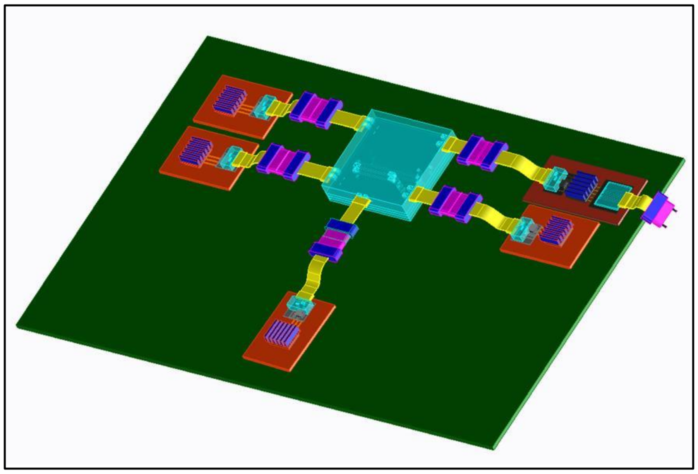
3. Intra-rack interconnections (2 m) transceiver banks with aggregate bandwidth of 1.7 Tb/s (32 channels at 56 Gb/s) that will be split in blocks of 8-fiber arrays operating at 56 Gb/s/ each channel, with consumption of 2.5 pJ/bit and bandwidth density greater than 30 Tb/s/cm^2
4. Edge transceiver banks for intra-data center interconnections (2000 m), with aggregate bandwidth of 1.7 Tb/s (32 channels at 56 Gb/s) that will be arranged in 4 wavelengths Coarse Wavelength Division Multiplexing (CWDM) at 56 Gb/s, with bandwidth density of 7 Tb/s/cm^2 and energy consumption of 6 pJ/bit
5. A novel on-chip optical connector that transforms the small mode of the silicon photonics waveguides into a low index contrast mode, pluggable to an optical fiber array by means of a standard connector (MPO or MTP), with good alignment tolerance and low overall loss
6. A novel approach for integrating lasers directly on the silicon photonics platform, combining advantages of classical flip chip integration and heterogeneous integration based on wafer bonding
7. Advanced photonic integrated circuits on 300 mm SOI wafers, with 3D electronic-photonic integration, 56 Gb/s applications, 40 GHz photodiodes and low power consumption modulators to reach the 2.5 pJ/bit overall target of energy consumption

Economical and societal benefits

The structure of TERABOARD project was chosen to strongly reinforce the cooperation among several research institutions and large companies, covering the full value chain from R&D to industrial product manufacturing to system applications. To ensure that every choice will be in line with industrial and market needs, in TERABOARD the work package responsibilities are assigned to experts coming from the industry. TERABOARD will directly contribute to strengthening European telecommunications capability and R&D pushing CMOS photonics integration density on a chip beyond the state of the art, in order to give a strategic benefit both at component and system levels. Thus, TERABOARD will guarantee not only support of competitiveness of European telecom industry at the technological level via strengthening its manufacturing base in photonics, but also will widen market opportunities in communication for data center arenas. TERABOARD will enable European telecom industry to stay at the forefront of electronics and photonics development and applications. Telecommunication networks are essential infrastructure of existing and future internet solutions. The success of telecommunications in the last 25 years and the ability of delivering an ever increasing capacity at reduced cost per bit allow predicting even further development. Telecommunication networks serve as the central linking infrastructure of the information-based society. TERABOARD project offers a clear contribution in transforming the communication network infrastructures into a versatile tool to support the knowledge-based economy by creating foundations for novel network infrastructure architectures. Furthermore, the higher energy efficiency will be the main point toward the reduction of CO_2 emissions. Data centers are currently on the top of the list of high power consuming infrastructures and have a significant impact on the amount of CO_2 emissions. Most of the power consumption is due to the communication network infrastructure, i.e. network switches. Extensive research is undertaken to reduce the total power consumption of data centers and simultaneously satisfy the growing need for bandwidth and computing resources. A possible solution is to limit the electronics in hardware infrastructure and exploit the recent advancements in optical transmission systems. Wavelength division multiplexing (WDM) optical transmission systems, though increase spectral efficiency, are power hungry. TERABOARD will limit their use only to the edge connections to reduce the cost of fiber array links, and will use grey links for intra-board connections. The reduction in power consumption enabled by the TERABOARD technology is achieved due to the lower power required to switch and keep on the networking apparatus, as well as lower power required for the cooling. The resulting 10-times reduction in power consumption will have a significant impact in reducing CO_2 emissions.

Summary

TERABOARD project is pushing the photonics integrated circuits (PIC) based on silicon photonics technology toward the new frontier of 3D stacking, suited for cost-effective volume manufacturing on semiconductor production lines merged with dielectric-based 3D photonic integration platforms. This will guarantee high-density modules and the aggregated bandwidth scalability to meet the market trends. At the same time TERABOARD, in line with 2020 market forecast, aspires to reach the goal of reducing the cost/gigabit by a factor of 16 and the power consumption, in terms of pJ/bit, by a factor of 10 with respect to the current available products in the market, approaching the level of 1 pJ/bit, together with 2 Tb/s of aggregated traffic per board. The proposed 3D interconnection technology will support radically new data center architectures requiring a reduced number of boards and backplanes, thus reducing the overall data center size and cost. This second challenge will reinforce the European industrial technology leadership through a relevant increase of market presence in high-bitrate optical communications for emerging exascale cloud data center, wireless and HPC applications. These two targets, once reached, will pave the way to Pb/s network throughput, enabled by scalable Tb/s board interfaces for optical intra-data centre transmission, and will let Europe to be more efficient and digital. The industrial partners of TERABOARD strongly believe in the strategic importance of the project to push photonics in integrating new functions to realize novel products and functionalities in Europe in order to compete with the rest of the world.



The silica based interconnection board, Starboard, between four processors and a switch ending on an edge connector

Innovative concepts are not enough to create innovation: it is essential to possess the capability to turn these ideas into tangible, marketable technology. TERABOARD was designed to do exactly this, taking a two-pronged approach: first, some consortium members have been carefully selected considering their track-record in innovation and commercialization, whereas others are competent in breakthrough technologies.

The combination of the two is the key to produce advancement in the field and to drive practical implementations. In TERABOARD the technology has to envisage the solution matching the application specifications. The research teams in TERABOARD will facilitate innovation with the deep cross disciplinary knowledge of photonics, electronics, packaging and optical communications that combined together will provide success to the project and generate value for the European community.

TERABOARD website

The project website was realized with the aim of obtaining an original and effective communication style. The website is located at:

http://www.teraboard.eu/

The necessary acknowledgments to the Photonics Public Private Partnership were optimized for a better graphic output, as well as the logotypes of the Consortium Partners. The resulting communicative style was adopted also to realize the layout of the Narrative Text, and it will be the base of any other future element of the Communication Kit.

TERABOARD website is constantly updated with news about the project, contains the necessary references to the Partners respecting the principle of fair visibility, and includes a Consortium private area where uploaded documentation can be accessed by the members.

Conclusions

In fulfillment of communication requirements, a Communication Kit of TERABOARD project is provided. In particular, an exhaustive Narrative Text was redacted and the official website of the project (http://www.teraboard.eu/) was launched. It contains the necessary information about the project and is constantly updated.