"Towards the neW era of 1.6 Tb/s System-In-Package transceivers for datacenter appLIcations exploiting wafer-scale co-inteGration of InP membranes and InP-HBT elecTronics"

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Topic: ICT-05-2019 Application driven Photonics Components

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Consortium:

- Institute of Communications and Computer Systems (GR) – Project Coordinator
- Technische Universiteit Eindhoven (NL)
- III-V Lab (FR)
- Kungliga Tekniska Hoegskolan (SE)
- Argotech (CZ)
- Mellanox Technologies (IL)

Project Website: https://ict-twilight.eu

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The Challenge

Rapidly growing cloud applications, big data, Internet-of-Things (IoT), artificial intelligence (AI) and machine learning are the main drivers for the explosion of datacentre traffic which is foreseen to reach 19.5 ZB per year by 2021 ramping up from 6 ZB in 2016. The majority of this traffic stays within the datacentre and accounts for 71.5% of the total with respect to 13.6% which account for the traffic exchanged from one datacentre to another [1]. The increasing traffic demands impose a huge problem for datacentre operators because on one hand they have to keep pace with the increasing speeds dictated by modern applications and on the other, they have to cope with the increasing power consumption that is required for airflow management and cooling [2]. The deployment of hyperscale datacentres to meet the vast amount of traffic growth within the datacentre environment is currently driving the market of 400GbE pluggable modules which is expected to grow fast by 2023 [3], while the next standards ratification for 800GbE and 1.6T are expected in the 2023-2024 timeframe [4]. Although 800GbE could be supported by the existing standard form factors and the speed of current photonics and electronics technologies based on 4-level Pulse Amplitude Modulation (PAM4), it is suggested that this will be the end of pluggable modules and the advent of co-packaging optics with ASICs that will pave the way to 1.6T and beyond [5].

Moreover, as datacentres grow in size, the number of interconnections in a typical 2- and 3-tier leaf-spine topologies grow as well, dictating the deployment of high-radix switches complying with the stringent low latency requirements of modern cloud applications. Optical space switches based on 3D MEMS is a well-established technology that offers a large number of input/output (I/O) ports

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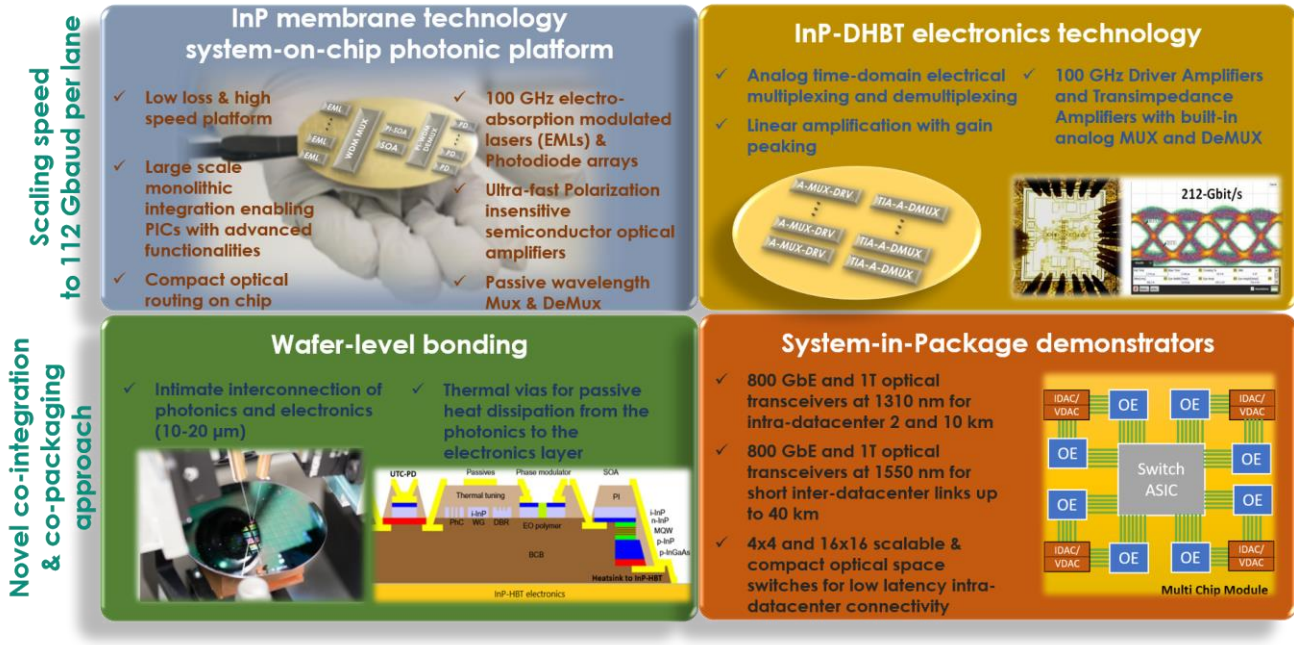

Figure 1: TWILIGHT concept, technologies and final demonstrators.

[6], still compact optical space switches consuming less space and less power per port are urgently sought.

Vision

Within this realm, TWILIGHT exploits a series of technological breakthroughs for the development of the new generation of photonics components and circuits and electronics ICs in combination with advanced co-integration and packaging concepts enabling faster, greener and cheaper datacenter connectivity. TWILIGHT vision is two-fold:

- Scaling the symbol rate of optical transceivers to 112 Gbaud per lane towards the development of 800Gb/s and 1Tb/s transceivers to serve the rapidly increasing cloud datacenter traffic in a power and cost-efficient manner.
- Scaling the number of I/O ports of optical space switches to interconnect the hundreds of Top-of-Rack (TOR) and spine switches within the datacenter environment by simultaneously reducing footprint and offering nanosecond response time.

Project Objectives

Empowered by its ambitious vision, TWILIGHT combines Indium Phosphide (InP) membrane photonic platform and Indium Phosphide Double Heterojunction Bipolar Transistor (InP-DHBT) technology and will develop:

- The next generation of Electro-absorption modulated lasers (EMLs) with 100 GHz electro-optic bandwidth driven by electronics driver ICs with gain peaking and built-in analog time multiplexing for interfacing with standard datacenter equipment and for generating 112 Gbaud PAM4 signals.
- 100 GHz photodiodes and >100 GHz transimpedance amplifiers (TIAs) with built-in analog time demultiplexing for signal reception.
- Polarization insensitive semiconductor optical amplifiers (PI-SOAs) for signal pre-amplification at the receiver side and ultra-fast all-optical switching within datacentres.
- Photonics Integrated Circuits (PICs) co-integrating active components and passives monolithically hence enabling complex functionalities on-board; development of arrays, wavelength multiplexing and demultiplexing, optical amplification and compact optical routing.

TWILIGHT will introduce co-integration of photonics and electronics at unprecedentedly close distances via wafer-bonding ensuring low loss and high speed signal integrity. Following its novel co-packaging

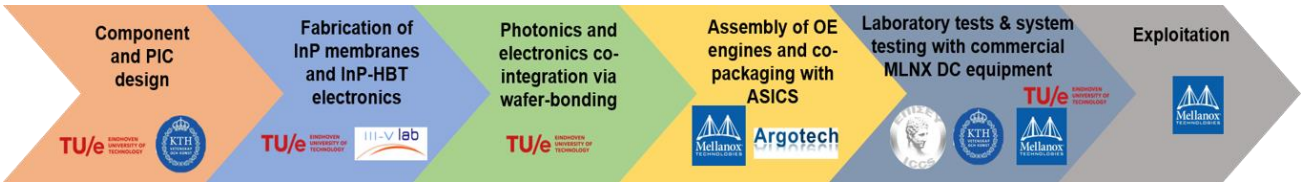

Figure 2: TWILIGHT value chain.

approach, TWILIGHT will bring the developed opto-electronic transceiver engines close to the ASIC chip complying with the concept of Multi-Chip-Modules (MCMs) i.e. the integration of several discrete components and electronics ICs onto the same substrate. In this way, optical transceivers will move away from the front panel of digital switches improving faceplate density, increasing the overall switch capacity and relaxing airflow and cooling requirements. In a ntushell, TWILIGHT will demonstrate:

- 800 Gb/s and 1.6 Tb/s system-in-package optical transceivers operating at the O-band (i.e. 1310 nm) for intra-datacenter connectivity over 2 and 10 km.
- 800 Gb/s and 1.6 Tb/s system-in-package optical transceivers operating at the C-band (i.e. 1550 nm) for short datacenter interconnect links up to 40 km.
- A 4x4 and a 16x16 scalable compact optical space switches for ToR and board-level intra-datacenter connectivity.

Impact

TWILIGHT will penetrate high-value markets and it will leverage significant power consumption savings (overall higher than 70% compared to currently available technologies), large footprint reduction (more than 50%) and competitive cost performance benefits. TWILIGHT optical transceiver technology will comprise a reliable short-term solution for the market of 400 GbE optical transceivers which is expected to grow at a Compound Annual Growth Rate (CAGR) of 13.5% between 2016 and 2022 [7] and it will also drive the next standard evolution for 800G and 1T MCMs. With respect to TWILIGHT optical space switch technology it targets the optical switches market which was valued at USD 5.27 billion in 2017 and is expected to reach USD 11.24 billion by 2023 at a CAGR of 13.41% over the forecast period 2018-2023 [8]. Finally, TWILIGHT has a profound impact on the overall PIC market which continues to rise, creating new business opportunities for TWILIGHT technologies in passive optical network (PON) and 5G fronthaul applications, metrology and sensing, ultra-fast optical switching in metro-access networks as well as 600G and 1T optical transceivers for coherent metro and long-haul applications.

TWILIGHT has a secured pathway to market and comprises a consortium of leading research institutes with industrially compatible technology platforms, top-of-rank universities and a major industrial player with a strong product portfolio in the datacenter and data-center interconnect markets, ensuring rapid exploitation of project foregrounds after the project end and European industrial leadership in photonic systems integration and photonic interconnect technologies.

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