Successful Project Completion and Achievements

After nearly 5 years of collaborative work, TWILIGHT project has ended. TWILIGHT was a Research and Innovation Action (RIA) Horizon 2020 ICT project funded by the European Commission under the Photonics Public Private Partnership (PPP), which addresses the transformation of datacenters to support the modern and emerging applications based on the Internet of Things (IoT), 5G and Artificial Intelligence (AI). TWILIGHT consortium committed to develop the underlying technologies for next generation optical transceivers and optical space switches for datacenter interconnects targeting a) 112 Gbaud per lane speed (i.e. up to 224 Gb/s using PAM4 modulation) and b) scalable ultra-fast port switching. TWILIGHT introduced significant innovations and advanced the state-of-the-art with respect to novel processes, components and systems, in alignment with industrial trends and standardization activities.

Achievements and Outcomes

- An advanced Selective Area Growth (SAG) technology was implemented on InP membrane platform, enabling multiple MQW bandgaps on the same wafer. DFB lasers were designed and fabricated with stable operation and high side-mode-suppression ratio (SMSR) across a record wavelength tuning range (1458.9 to 1592.4 nm).
- Thermally shunted electro-absorption modulated lasers (EMLs) were designed and fabricated with significantly reduced thermal resistance and enhanced dissipation efficiency, improving the operation stability and longevity under high-power conditions.
- Polarization insensitive semiconductor optical amplifiers (PI-SOAs) were designed and fabricated showing low polarization dependence.
- Uni-travelling-UTC-photodiodes with close to 60 GHz bandwidth and low dark current (nA level) were developed.
- Monolithic integration of an analog multiplexer (AMUX) and a linear driver (AMUX-driver) has been realized exhibiting record gain-bandwidth (2.08 THz), PAM-4 output swing (2.4-Vppd). Operation of the AMUX-driver up to 160 GSa/s was demonstrated without any support of DSP or equalization. A second generation of AMUX-driver IC was designed and fabricated in the 0.5-µm InP DHBT baseline technology and showed 4-Vppd output swing at 100 GBd in NRZ. Both AMUX-driver IC generations show among the highest performances reported to date in terms of driving efficiency with respect to the current state-of-the-art.
- An analog demultiplexer (ADeMUX), processed in the 0.5-µm InP DHBT, has shown 50-GSa/s PAM-4 operation with up to 1-Vppd linear output swing, without any support of DSP nor equalization.
- A new TiW-emitter InP DHBT technology has been developed with high performances and high yield, paving the way for future <300 nm emitter nodes. A linear driver and an AMUX-driver designs have been fabricated with the TiW-emitter-based 0.5-µm InP DHBT technology. The linear driver showed a 3.2-Vppd linear PAM-4 output swing at 64 GBd with about 97% IC-yield across the 3-inch wafer. The AMUX-driver showed a 2.3-Vppd PAM-4 output swing at 100 GSa/s and ~40% IC yield.

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- TWILIGHT has achieved one of its most challenging and innovative milestones which is the development and validation of a significantly improved process flow for the co-integration of photonics and electronics components at wafer scale and for the first time for InP-to-InP technologies. High accuracy post bonding alignment (~ 2µm) was achieved relying on soft-baked anchors.
- Assembly on ceramics interposers was performed for the transmitter, receiver and 8x8 switch modules as well as full printed-circuit-board assemblies (PCBAs) were produced hosting the driving and control electronics.
- Performance evaluation was carried out both at chip- and at module- level. System experiments exploited the developed DSP toolkit.

Impact on the European Community

The outcomes of TWILIGHT have a significant impact in the development of 1.6T and 3.2T co-packaged optical transceivers and scalable fast optical space switches for datacenter interconnect networks. For the optical transceivers, cost analysis based on TWILIGHT technologies is in alignment with the 1.6 Tb/s transceiver cost market estimates (assuming high volumes ~250k units per quarter). For the 8x8 switches a significant undercut of the cost/port pair with respect to commercial devices was estimated (assuming medium volumes ~1k units per quarter).

TWILIGHT impacts extend beyond the scope of the project. More specifically, the post-bonding alignment process using micro-anchors for wafer-scale adhesive bonding comprises a versatile method which can be used for several device and packaging applications (Dutch patent No. 2032112). The component models developed for the DFBs/EMLs and the parameter extraction process from the fabricated structures resulted in the design of bandwidth enhanced directly modulated lasers (DMLs) with tunable photon-photon resonance which were fabricated on the InP membrane platform. The InP DHBT AMUX-driver and ADeMUX are relevant for other applications as well (e.g. coherent transceivers, or system upgrade of legacy SerDes ASIC). Finally, the developed optical switches pave the way for the development of a modular switching photonic integrated platform on InP membrane technology which can be also exploited in optical metro network applications.

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