PICaboo!

"Photonic Integrated Circuits on InP technology plAtform enaBling low cost metro netwOrks and next generation PONs"

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Topic: ICT-37-2020 Advancing photonics technologies and application driven photonics components and the innovation ecosystem

Duration: 1st Jan. 2021 – 31st Dec. 2023 (36 months)

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Consortium:

- Institute of Communications and Computer Systems (GR) – Project Coordinator
- Technische Universiteit Eindhoven (NL)
- III-V Lab (FR)
- VLC Photonics Sociedad Limitada (ESP)
- NOKIA Solutions and Networks GmbH & Co KG (DE)
- ADVA Optical Networking SE (DE)

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

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The Challenge

Indium-Phosphide (InP) Photonic Integrated Circuit (PIC) technology has been the workhorse for the development of optical transceivers for metro/core and access networks due to its high-speed operation potential and its capability for large scale monolithic integration [1], [2]. Despite its high-performance characteristics e.g. component electrooptic bandwidth and ultra-fast response, it is considered inherently an expensive technology compared to silicon photonics which relies on low cost CMOS processes. Significant efforts towards decreasing development costs and lowering the boundaries for fast prototyping is pursued via the JePPIX pilot line, the EC manufacturing pilot line project for photonic integrated circuits based on InP, through open access to multi-project-wafer (MPW) runs from its foundries [3]. European InP foundries have specific process design kit (PDK) libraries including building blocks which can be used from designers in order to develop application-specific PICs with predictable performance. The aggregation of multiple functionalities on a single chip is very important for bandwidth-hungry cloud and IoT applications considering that transceiver capacity can easily be increased via channel parallelization and multiplexing of the optical wavelengths, yielding in tandem significant cost benefits due to the reduced assembly complexity and its associated costs. Moreover, scaling to larger capacities usually implies the need for stronger digital signal processing (DSP) both at the transmitter and at the receiver side, which in turn increases the overall power consumption and dictates larger requirements for cooling and airflow management at the front panel of digital

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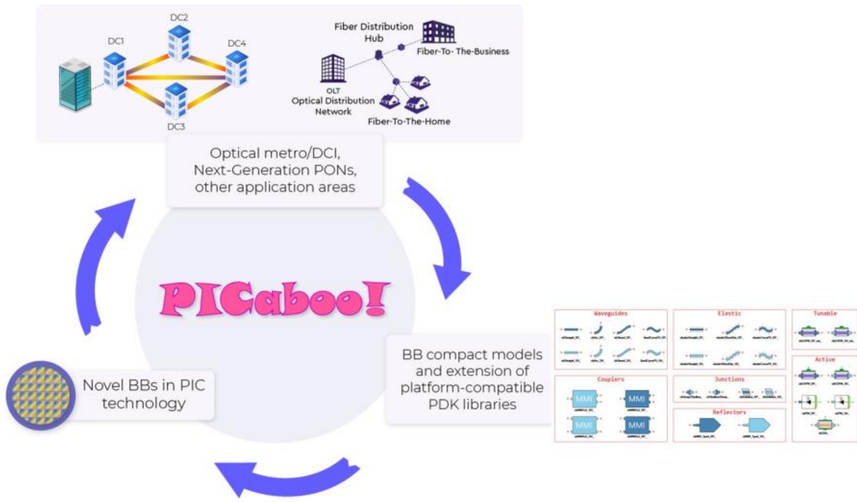

Figure 1: PICaboo vision.

switches. Optical signal processing has been extensively researched in the past decades towards the realization of transparent all-optical networks via complex functionalities like all-optical regeneration, all-optical switching etc. [4], [5], [6] but the advent of coherent technologies after 2010 widely deployed in metro and longhaul networks addressed most of these by means of electronic DSP. In the access networks, simple intensity modulated direct detection (IM/DD) technologies have been widely deployed at low speed (GPON, XGS-PON) however, this scenery will rapidly change considering the fast uptake of 5G and 6G services.

Vision

Within this ecosystem, PICaboo steps in to develop novel building blocks based on the generic foundry model that will transform the optical metro and access networks in terms of speed, footprint, power consumption and cost. Application-specific PIC demonstrators, will be designed, fabricated and validated, leveraging enhanced signal processing functionalities on chip and scalable performance. Taking a step forward, PICaboo will develop compact models for all its building blocks that will be included in PDK libraries compatible to the platforms of TUe and III-V Lab after the end of the project. These models will be also exploited to investigate the applicability of the developed building blocks in other application areas.

Project Objectives

Empowered by its ambitious vision, PICaboo will:

- Develop a polarization handling toolbox on the InP technology platform of TUe enabling full manipulation of the signal polarization on InP PICs.
- Develop balanced photodetectors, photodetector arrays and widely tunable low-linewidth laser on the InP platform of TUe.
- Develop a high-speed Selective-Area Growth enabled PIC platform operating in the O-band based on the InP SIBH technology of III-V Lab.
- Develop low-loss passive structures, high-speed EAMs with a 3 dB bandwidth of 65 GHz, gain sections with enhanced peak gain and DFB lasers with low-threshold currents on the SAG-SIBH platform of III-V Lab.
- Generate compact physical models of the developed building blocks in the form of PDK-compatible libraries.
- Develop a dual polarization coherent receiver PIC enhanced with all-optical DSP functions for optical metro networks and DCI applications. PICaboo's receiver-side PIC demonstrator will reduce the overall transceiver power consumption by more than 30% with concurrent cost benefits of 3.6x compared to standard coherent transceivers.

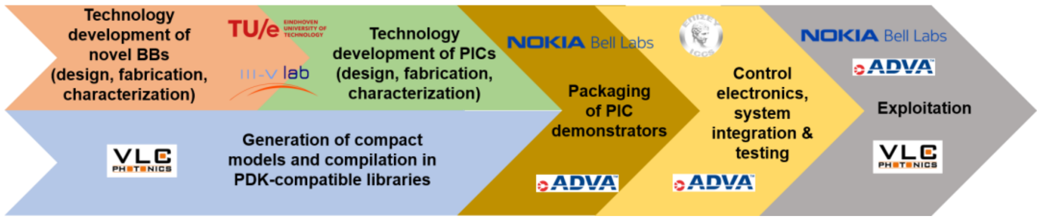

Figure 2: PICaboo value chain.

- Develop EAM-based transmitter PICs with all optical pre-equalization on-chip for next generation PONs and 5G/6G fronthaul applications. The single EAM-MZM transmitter and the coherent EAM-IQM transmitter PICs that will be developed will leverage power consumption reduction of 50% and 65% respectively, compared to 50G EML-based solutions, whereas both will demonstrate an overall cost reduction by almost 20%.
- Validate the developed PIC demonstrators and exploit the project foreground in relevant application areas.

Impact

PICaboo will bring significant advances on the InP PIC technology platforms of its foundries by developing novel building blocks that will achieve unprecedented performances enabling in turn the development of application specific optical sub-circuits and PIC demonstrators with attractive features. The exploitation of available building blocks in the PDK libraries reduces the design and test time of PICs by 30% whereas decreases the cycle count of iterations by at least one full round.

PICaboo coherent receiver PICs make a perfect fit for near-term exploitation in 100Gb/s and 200Gb/s Ethernet optical transceivers which are expected to grow at a Compound Annual Growth (CAGR) of 22% between 2019-2024. Furthermore, considering that 400GbE transceivers will comprise a fast-growing trend in the DCI market, which is expected to grow at a CAGR of 11% over the forecast period of 2018-2023, PICaboo will constitute an attractive technology with long term exploitation potential. This is even more pronounced with the ratification of 400ZR standard for distances within 10-80 km [7]. PICaboo single EAM-MZM transmitter technology targets the NG-PON equipment market which is expected to approach USD 8.4 billion in 2025 at a CAGR of 4.3% from 2018 to 2025. The EAM-IQM transmitter targets up to 400Gb/s capacity while the 4-array EAM-IQM can offer up to 1.6Tb/s comprising a future-proof and scalable solution for emerging 6G fronthaul applications. PICaboo technologies can be directly exploited in other application areas such as sensing, optical transceiver pluggables for intra-datacentre interconnects and neuromorphic photonics. The developed compact models will be exploited for investigating the potential use of novel components in reference PIC designs for a variety of emerging applications.

PICaboo has a secured pathway to market and comprises a consortium of two top-of-rank universities, one world-class oriented research institute, one world-leading design house and two major industrial partners with a strong product portfolio, ensuring rapid exploitation of project's foregrounds. To this end, PICaboo will put Europe in the driver seat of optical transceivers' market for metro/DCI and PON applications.

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