ICT-STREAMS: WDM-based on-board optical interconnects for chip-to-chip communication

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Summary

The article presents the overall vision, main research targets and major results obtained so far within the European project Horizon-2020-ICT-STREAMS, launched February 2016.

Introduction

The next generation optical interconnects will focus on embedded optical transceivers, placed on-board and in close proximity to the electronic modules, as a way to enhance their performance and drastically reduce the required physical space and power budget.

Following this trend, ICT-STREAMS research project targets the deployment of a holistic mid-board transceiver and router device portfolio exploiting silicon photonic technologies and introducing WDM both as a capacity-enhancing as well as a low-energy routing mechanism. It aims to deliver a 1.6 Tb/s mid-board transceiver together with a 25.6 Tb/s-throughput mid-board routing engine onto the same electro-optic PCB, releasing a point-to-point-linked 16-socket server board, increasing server-board density and throughput by a factor of x4 and x16 respectively, with 10 fold reduced energy consumption.

Targeted Technology Breakthroughs

The technological advancements in ICT-STREAMS span within three layers of system hierarchy: architectural level, component level and device manufacturing. On the architectural side, ICT-STREAMS will introduce a passive WDM routing module to the board level in order to transform the WDM parallel transmission concept to a powerful routing technology that will allow massive, on the fly, any-to-any connectivity.

Fig. 1. ICT-STREAMS on-board chip-to-chip optical interconnect concept
On the component level, ICT-STREAMS will develop a set of innovative technologies for 1) the optical engines: Silicon photonics transceivers will exhibit increased number of WDM channels and line data rate up to 50Gb/s, 2) electro-optical PCB: a single mode polymer Electro-Optical PCB will allow high-density, high-frequency RF and optical I/O interfaces 3) laser sources: in plane III-V on Si WDM laser arrays will be developed with a CMOS compatible process 4) Amplifiers: PhC-SOA nanoamplifiers with reduced footprint and power consumption will introduce a new amplification paradigm allowing for deploying advanced features and smart routing functionalities to the on-board optical links 5) a thermal drift compensation system: a non-invasive wavelength monitoring and control technology for WDM Silicon Photonics components will bring significant impact on the real-life applicability of Si-Pho technology.

On the fabrication level, ICT-STREAMS aims to enhance the manufacturability of photonic devices and systems, by developing concepts that will minimize the required assembly processes. To this end, adiabatic coupling between silicon chips to polymer boards for the new generation of embedded optical modules aims to enable single step chip-to-board assembly, relaxing manufacturing time and cost requirements. On the other hand, in plane III-V to Si lasers manufacturing aim to completely embed the gain structure in the back-end of the line (BEOL) process steps to make the laser fabrication method fully CMOS compatible. The monolithically integrated in-plane lasers will require no mechanical beam alignment to the Silicon chip.

**Project results and proposed talks**

1) George T. Kanellos from the Aristotle University of Thessaloniki in Greece will give an overview of the project covering the overall motivation and concept of ICT-STREAMS, the technical objectives and main achievements regarding the on-board chip-to-chip optical interconnection.

2) Roger Dangel from IBM Zurich will report on the optimization of a scalable optical interfacing approach for silicon photonics based on adiabatic optical coupling between tapered silicon waveguides and single-mode polymer waveguides. Different taper-designs and assembly methods were investigated to minimize the coupling loss for both polarizations. The presentation will demonstrate very low coupling losses per interface down to < 1.0 dB for TE and < 0.5 dB for TM across the entire O-band.

3) Ruiyong Zhang from Amphenol FCI will report on the assembly of silicon photonic chips with multiple optical and electrical channels on electrical optical printed circuit boards (EOPCB). This is a very challenging process because of the critical optical alignment accuracy, while the performance of the electrical high frequency interfaces needs also to be guaranteed. By application of pressure and temperature for the assembly, an electromechanical bond is formed in-between the optical die and the substrate. The correction in X and Y direction is executed via alignment of fiducial marks and the alignment in Z direction is performed by referencing the silicon waveguide structure on top of the polymer waveguide structure. The presentation will also review the EO assembly and packaging methods, where cost and reliability aspects will comprise decisive factors and will be evaluated throughout the development of the individual processes.

4) Finally, Fabrice Raineri from LPN-CNRS will report on III-V-on-Silicon, electrically pumped photonic crystals nanocavities and their potential application as nano-lasers and nano-amplifiers.