Advanced photonic integrated circuit building blocks for reconfigurability in hyperscale data centres - INVITED

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Abstract. In this talk we introduce two new European projects DYNAMOS and ADOPTION, which will develop advanced integrated photonic technologies for WDM hyperscale data centre architectures including a novel stamped metallic micro-mirror array for advanced PIC-to-fibre coupling with the potential to dramatically reduce PIC design and assembly costs. We also discuss international standardization efforts for these corresponding optical interconnect technologies for future hyperscale data centre, HPC and 6G and Quantum environments.

1 Horizon Europe projects

Horizon Europe is the current seven year European framework programme for collaborative research and innovation taking place during the period 2021 to 2027 with total budget of €95.5 billion.

1.1 DYNAMOS project

The DYNAMOS project full title is: “Dynamic And Reconfigurable data centre networks with Modular Optical Subsystems”. DYNAMOS develops fast (1 ns) and widely tunable (>110 nm) lasers, energy-efficient (~ fJ/bit), broadband (100 GHz) electro-optic modulators, and high-speed (1 ns) broadcast-and-select packet switches as photonic integrated circuits (PICs). The project meets the expected outcome objectives and call scope by proposing the development of low energy (few pJ/bit) PICs, which are integrated into modular and scalable subsystems, and subsequently utilized to demonstrate novel data centre networks with highly deterministic sub-microsecond latency to enable maximum congestion reduction, full bisection bandwidth (lower congestion) and guaranteed quality of service while reducing cost per Gbps. The proposed network offers optical circuit switched reconfiguration and guaranteed (contention-less) full-bisection bandwidth, allowing any computational node to communicate to any other node at full-capacity.

DYNAMOS builds on recent developments in III-V optoelectronics, thick silicon-on-insulator waveguide technology, and silicon organic hybrid (SOH) modulators. It co-develops the entire ecosystem of transceivers, switches and networks to boost overall performance and to reducing the total cost of data exchange, instead of focusing on the improvement of individual optical links or interfaces.

There are 10 partners in the DYNAMOS project. VTT Technical Research Centre of Finland will coordinate the project. VTT is the largest research and technology company and research centre conducting applied research in Finland. They will also be leveraging their thick SOI technology [1] offering an alternative to conventional silicon photonic waveguides with lower propagation loss (~0.1 dB/cm), reduced polarization sensitivity and the capacity to handle higher optical power without exciting nonlinear losses.

Almae in France will design and manufacture tuneable III-V lasers, while SiLORiX in Germany will leverage its extensive expertise on silicon organic hybrid modulator technologies [2]. Ligentec in Switzerland will provide advanced, low-loss silicon nitride PIC platforms for wavelength traffic routing. Argotech (in the Czech Republic will provide photonic packaging and assembly services. Resolute Photonics in Ireland and Senko Advanced Components in the UK will develop the standardised pluggable subsystems integrating these different photonic integrated circuit technologies to allow them to be deployed in a flexible and reconfigurable manner in a hyperscale data centre system, in order to implement the advanced WDM architecture, developed by University College London in the UK [3]. Finally SME E4 in Italy will advise on data centre design, while Huawei in France will provide overall future network requirements.

1.2 ADOPTION project

The ADOPTION project has the full title “Advance co-packaged optics enabling high-efficiency cloud
computing”. ADOPTION is a three year project to develop advanced co-packaged optoelectronics solutions. The collaboration partners are as follows: Tyndall Institute in Ireland will coordinate the project. The partners are IMEC in Belgium, Resolute Photonics and Pilot Photonics in Ireland, Senko Advanced Components in UK, Technical University Eindhoven and Microalign in the Netherlands, Argotech in Czech Republic, and Fraunhofer IZM and Huawei Technologies Duesseldorf in Germany.

1.3 Metallic photonic integrated circuit connector
A range of disruptive new interconnect technologies will be introduced in both European projects. One important example will be the Metallic Photonic Integrated Circuit (PIC) Connector (MPC) developed by project partner Senko. The MPC is an all-metallic stamped component that serves as a rigid template for optical assemblies. MPCs are stamped with sufficient tolerances to accurately hold single-mode optical interconnect components including SM fibres, micro-mirrors, micro-lenses, filters and other optical elements. They can be made of metals with low coefficients of thermal (CTE) expansion and tuned to match single-mode optical packaging requirements. In the example shown in Figure 1a, the MPC unit includes mounting grooves for single-mode fibres and an array of stamped micro-mirror arrays to redirect, focus, expand and reshape light coupled out of the PIC into the fibre and vice versa. In particular, the ability to create almost arbitrary micro-mirror surface topologies including aspherical surfaces allows the optical mode profile to be altered to optimize coupling. This means that coupling losses that could only be achieved with advanced PIC grating couplers requiring expensive sub-wavelength features can now in principle be achieved with lower cost PICs using simpler larger diffraction features. Since the shape of each of the mirror can be customized, the MPC can be tailored on a per-channel basis for low-loss coupling between the PIC and the optical fibre. This is particularly useful when the MPC unit must accommodate a mixture of fibres for transmission, receive and external CW light sources.

![Figure 1: Stamped metallic micro-mirror array. a) photo of metallic PIC coupler (MPC) b) schematic of MPC to MPC characterisation](image)

The test set-up shown in Figure 1b allowed the coupling loss between two MPC elements placed in a periscope arrangement to be measured across each MPC channel pair of an array of eight metallic micro-mirrors. The coupling loss measurements are shown in Table 1.

<table>
<thead>
<tr>
<th>Channel #</th>
<th>Coupling Loss / dB</th>
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<tbody>
<tr>
<td>1</td>
<td>1.23</td>
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<tr>
<td>2</td>
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<tr>
<td>8</td>
<td>1.34</td>
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<tr>
<td>Average</td>
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</tbody>
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2 International standardisation
The international standards landscape covering optical communication is substantial involving all mainstream international standards bodies including ITU, IEC, ISO, ETSI, IEEE, CEN/CENELEC and more. In these projects the partners will focus on developing new standards in one of the largest mainstream standards groups for optical communications technologies, namely IEC Technical Committee 86 – Fibre Optics, which prepares standards for fibre optic systems, modules, devices and components intended primarily for use with communications equipment.

References

