Fraunhofer
IZM

FRAUNHOFER INSTITUTE FOR RELIABILITY UND MICROINTEGRATION IZM

PRESS RELEASE

L3MATRIX Large Scale Silicon Photonics Matrix for Low Power and Low Cost Data Centers

The research and innovation project L3MATRIX, "Large Scale Silicon Photonics Matrix for Low Power and Low-Cost Data Centers", as co-funded by the Horizon 2020 Framework Programme of the European Union – 'ICT-27-2015 - Photonics KET', completed successfully its activities. The L3MATRIX project delivered a solution to challenges related to scaling, latency and the optical reach, enabling a smooth transition to low-cost and low-power Pb/s scale networks.

The European Union's Horizon 2020 Framework Programme project L3MATRIX provided a new method of building switching elements for Data Centers that combined a high radix connectivity architecture with an extended bandwidth of 25 Gb/s in single mode fibres and waveguides with low latency. The outcome of this approach is that large networks, in the Pb/s scale can be built as a single stage, non-blocking network.

The ever-growing increase in global internet traffic imposes significant challenges on data centre (DC) operators and equipment manufacturers. An almost exponential growth is found for both intra- and inter-DC traffic originating from the continuous growth of cloud-based applications, social media and big data analytics. Modern DCs utilize hundreds of thousands of servers in several hierarchy layers which require an efficient interconnection network which is both low-cost and energy-efficient. In addition, the switching platforms must support the high bandwidth required for large scale non-blocking topologies. These severe requirements are difficult to fulfil using conventional electronic packet switching and copper-based interconnection technologies with the main limitations arising from high power consumptions, limited reach and increasing latency. The introduction of photonic technologies to the DC in the last years resulted in significant performance enhancement. However, the traffic increase requirements outpace the technological capabilities and new approaches were needed. Precisely addressing these challenges, the now successfully completed EU project "L3MATRIX" devised solutions for cost reduction, efficiency and performance.

The L3MATRIX project provided novel technological innovations in the fields of silicon photonics (SiPh) and 3D device integration. The potential for network scaling to the Pb/s range is demonstrated by co-packaging the optical interconnects with the

Press
Georg Weigelt | Fraunhofer Institute for Reliability and Microintegration IZM | Phone +49 30 46403-279 |
Gustav-Meyer-Allee 25 | 13355 Berlin | www.izm.fraunhofer.de | georg.weigelt@izm.fraunhofer.de |

switching ASIC, thereby increasing the chip radix. The latter is the main limit to bandwidth scaling. The optical interconnect is implemented as a large, two-dimensional SiP matrix that provides both the required data density based on the parallel layout of the device, and long reach as it is a single mode optical solution. Packet parsing and switching is assigned to the ASIC. This solution is both low-cost and low-power due to the vertical integration of the optical matrix and CMOS logic chip. The on-chip assembly of the optical interconnect transceiver is a natural evolutionary step in the optical interconnect industry.

The outcome of this long reach photonic-digital integration 'co-package' is the creation of radically new system and network architectures that enable scaling of the network to Pb/s scale using a fraction of the devices that would be needed otherwise. The result is a 10× reduction of the power consumption since the number of switching devices is lower compared to the conventional technology. Latency is greatly reduced into the 10-20 ns range as the number of hops that a packet needs to make is smaller since less switching layers are being deployed in the network.

During a period of 42 months, the L3MATRIX project brought together leading European companies, universities, and research institutes with great expertise and experience in silicon photonics, III-V materials, and 3D device integration. The consortium was led by Fraunhofer Institute for Reliability and Microintegration IZM as project coordinator and Dust Photonics (Israel) as technology manager. Further partners were ams AG (Austria), IBM Research GmbH (Switzerland), Aristotelio Panepistimio Thessalonikis (Greece), University Politecnica de Valencia (Spain), Bright Photonics BV (Netherlands), and University College London (United Kingdom). The novel approach focused on embedding III-V sources on the SOI substrate which eliminates the need to use an external light source for the modulators and their co-integration with the switching ASIC. L3MATRIX provided a new method of building switching elements that are both high radix and have an extended bandwidth of 25 Gb/s in single mode fibres and waveguides with low latency. The power consumption of DC networks built with these devices is 10-fold lower compared to the conventional technology. The overall research and development budget of the project was about 3.8 Million € with 3.1 Million € EU contribution, which allowed an effort of more than 420 person-months for the duration of the project.
In May 2019 the project finished successfully, realising breakthrough developments of the L3MATRIX consortium as a whole.
The outcome of the L3MATRIX project was to demonstrate the basic building blocks of a co-packaged optical system. Two dimensional silicon photonics arrays with 64 modulators were fabricated in the fab. Novel modulation schemes based on slow light modulation have been developed to assist in achieving efficient performance of

Project Leader
Tolga Tekin I Fraunhofer Institute for Reliability and Microintegration IZM I Phone +49 30 46403- 639 I
Gustav-Meyer-Allee 25 | 13355 Berlin | www.izm.fraunhofer.de tolga.tekin@izm.fraunhofer.de I

the module. Integration of DFB laser sources within each cell in the matrix was demonstrated as well using wafer bonding between the InP and SOI wafers. Packaging of these 2D photonic arrays in a chiplet configuration has been demonstrated using a vertical integration approach in which the optical interconnect matrix was flipchip assembled on top of CMOS mimic chip with 2D vertical fiber coupling. The optical chiplet was further assembled on a substrate to facilitate integration with the multi-chip module of the co-packaged system with a switch surround by several such optical chiplets

A proactive Intellectual Property Rights management strategy was successfully deployed resulting in L3MATRIX foreground innovations being captured in 6 patents.

Regarding the dissemination of L3MATRIX foreground knowledge to the scientific community, during the lifetime of the project, more than 45 publications in journals were generated and more than 50 “other dissemination actions” that included invited talks to prestigious conferences in photonics, workshop presentations etc. Moreover, L3MATRIX organized 3 successful Symposia on Optical Interconnects with more than 150 attendees at each event.

The main project results and technologies are now available to small and medium-sized enterprises for further development, for deep characterization of system embedded photonic interconnect and for validation in data centre environments within ‘PhoxLab - European Photonics Innovation Hub for Optical Interconnects’ at the Fraunhofer IZM in Berlin.

L3MATRIX consortium partners:

- Fraunhofer Institute for Reliability and Microintegration, Germany (Fraunhofer IZM)
- ams AG, Austria (AMS)
- IBM Research GmbH, Switzerland (IBM)
- Aristotelio Panepistimio Thessalonikis, Greece (AUTH)
- Universitat Politecnica de Valencia, Spain (UPV)
- Bright Photonics BV, Netherlands (BP)
- University College London, United Kingdom (UCL)
- DustPhotonics Ltd, Israel (DPH)

More information about the project goals and highlights can be found on its website www.l3matrix.eu .

Project Leader
Tolga Tekin | Fraunhofer Institute for Reliability and Microintegration IZM | Phone +49 30 46403- 639 |
Gustav-Meyer-Allee 25 | 13355 Berlin | www.izm.fraunhofer.de tolga.tekin@izm.fraunhofer.de |

For further information, please contact: Dr.-Ing. Tolga Tekin, Fraunhofer Institute for Reliability and Microintegration IZM, Gustav-Meyer-Allee 25, 13355 Berlin, Germany, email: tolga.tekin@izm.fraunhofer.de

L3MATRIX project was co-funded by the Horizon 2020 Framework Programme of the European Union with Grant Agreement Nr. 688544.
https://cordis.europa.eu/project/rcn/199186/factsheet/en

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

L3MATRIX project is an initiative of the **Photonics Public Private Partnership**
www.photonics21.org

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. At present, it maintains 72 institutes and research units. The majority of the 26,600 staff are qualified scientists and engineers, who work with an annual research budget of 2.6 billion euros. Of this sum, 2.2 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Fraunhofer IZM specializes in industry-oriented applied research. With four technology clusters, Fraunhofer IZM covers the entire spectrum of technologies and services necessary for developing reliable electronics and integrating new technology into applications. Our customers are as varied as the applications for electronics. We take on development projects for the automotive industry, healthcare and industrial electronics and even textile companies. Fraunhofer IZM has two sites in Germany. Apart from its headquarters near Berlin Mitte, the institute is also represented in Dresden, a strategically important centers for electronic development and manufacturing.

Project Leader
Tolga Tekin l Fraunhofer Institute for Reliability and Microintegration IZM l Phone +49 30 46403- 639 l
Gustav-Meyer-Allee 25 | 13355 Berlin | www.izm.fraunhofer.de tolga.tekin@izm.fraunhofer.de l