MEKOPP

Metrology Equipment for critical scale up of PIC Production

Photonic integrated circuits (PICs), combining photonics with chips, are a technology for which the Netherlands enjoys a leading position. With chips that use light instead of electricity, many new and improved applications can be realised in healthcare, energy, automotive, agrifood and IT. PICs also drive the global internet infrastructure and are highly suitable for the large amounts of data collected and combined in the Internet of Things. The MEKOPP project will therefore facilitate sustainable economic growth by preparing metrology equipment for the efficient production of PICs and reduction of production defects.

In doing so, MEKOPP brings together ten expert partners and focuses on two machines: a Photonics Test Prober and a Photonics Visual Inspection Tool. These will enhance PIC production sustainability, potentially reducing material, energy and water usage by 50%. Indirectly, the project will contribute to PIC market adoption and scaling, which are vital for digital communication infrastructure efficiency. And with an expected 21-31% year-on-year market growth for PICs, the consortium expects to achieve an annual revenue of over €100 million by 2030 and create ~400 jobs in the eastern Netherlands.

EUROPEAN UNION
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OPoost
operationeel programma oost
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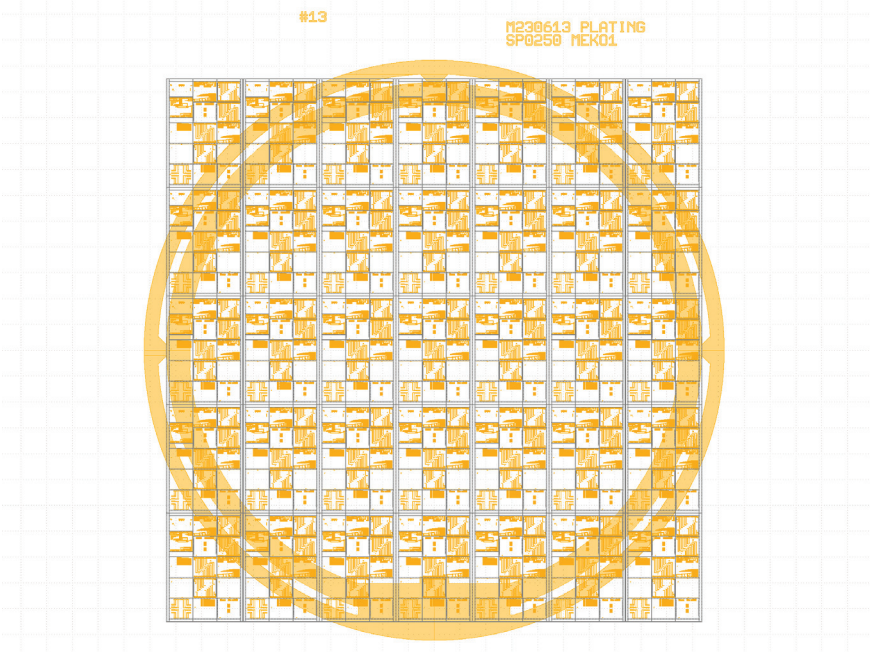
Collaborative by design: the PITC and the MEKOPP project

In 2021, the Photonic Integration Technology Center (PITC) was established as an applied R&D centre to bridge state-of-the-art expertise on integrated photonics with the industrial needs of today and tomorrow. The PITC Metrology Programme is an ongoing shared research agenda that includes a wide range of industry partners that cover the supply chain of integrated photonics; collectively, they work on challenges concerning the test process in the production flows for integrated photonics. This made the PITC an ideal partner for the MEKOPP project.



Top metallisation layer of a full mask set used for the production of the 4" InP wafer batch for the development of the MEKOPP test and inspection systems.

A common path

As a joint initiative of Eindhoven University of Technology, the University of Twente, TNO and PhotonDelta, the PITC is more than familiar with collaboration across different organisations, locations and specialisms. These founders provide it not just with a strong foundation in integrated photonics and shared innovation but also with shared technology programmes and infrastructure, jointly defined roadmaps and targets, and multi-year collaboration contracts with clear agreements on intellectual property ownership and deployment. Such collaboration is also the origin of the aforementioned Metrology Programme, one of the ways in which the PITC aims to shorten the path to the commercial application of integrated photonics.

The objectives of this applied R&D programme fit perfectly with the goals and development activities of MEKOPP, particularly in regard to metrology methods, processes and systems for producing integrated photonics. Within the project, PITC staff were engaged in drafting the Photonics Test Prober (PTP) and Photonics Visual Inspection Tool (PVIT) system specifications, developing the test software modules,

and planning, designing and acquiring validation material fabricated using a next-generation production node. This took the form of a batch of four-inch indium phosphide (InP) wafers from a commercial photonics foundry. Such wafers are now used for the development and validation of these in-production test and inspection systems.

Cooperating on challenges

One of the challenges that the PITC team had to deal with was the design process of the mask set for the InP wafer batch. These wafers include several unique cells that are optimised for the development of the PVIT and PTP systems. The design team at PITC worked closely with relevant MEKOPP partners – such as Nobleo, Settels Savenije, Salland Engineering, LioniX International, Workfoor and IMS – to capture all of the specific aspects. The resulting devices under test and standardised test protocols follow the design of experiment (DoE) methodology in order for the wafers to deliver the best possible results.

At the same time, the PITC team worked with the process and mask engineers at SMART Photonics, the supplier of the InP wafers, to maximise the output from the next-generation production node following the process design kit (PDK) rules and in adherence to the foundry design rule check (DRC). As a part of tight collaboration with the foundry, parts of the InP wafer batch were delivered from carefully selected intermediate production steps, in addition to fully processed InP wafers. In such a way, the processes and modules developed in MEKOPP are truly relevant to in-line, in-production inspections.

The PITC's collaboration in MEKOPP also extended to other challenges and objectives. With Nobleo, Settels and IMS, work was done on the wafer-scale visual inspection system, employing novel techniques that are truly optimised for integrated photonics, while IMS also collaborated on wafer handling for in-production deployment. Salland Engineering's work with the PITC resulted in one of the first on-the-market automated test equipment for integrated photonics, an SMU card in the industry standard form factor. Finally, Workfloor and the PITC teamed up on the integration of a standardised definition of test processes in the software frameworks for industry-grade, in-production test and inspection systems. Such strong cooperation was only possible through the efforts of the PITC team consisting of Dima Putakhod, Léa Chaccour and Ruud Jansen under the leadership of project coordinator Sylwester Latkowski.

Demonstrating credibility

As MEKOPP came to a conclusion at the end of 2023, the planned activities are now complete. However, many innovations will still undergo practical verification and validation in an experimental environment. The majority of the outputs of the project will ultimately contribute to the further evolution of the system developed and will be streamlined towards market-ready products. In addition to this primary objective, the common developments across the MEKOPP consortium have greatly contributed to the knowledge and know-how in the PITC Metrology Programme and will aid this in maintaining its excellence in the field.

Beyond the technology itself, the PITC expects increased involvement in the wider photonics ecosystem and new partnerships due its enhanced credibility as an R&D partner. Much of this is attributable to the maturing and expanding capabilities of the in-production inspection and test systems, as well as the growing demand for integrated photonics as part of semiconductor microelectronics. Through participation in MEKOPP – a resounding success story in this domain – the PITC has been able to demonstrate that its expertise is world-class.

MEKOPP project partners

IMS
Development of equipment for high-precision positioning of Photonic Integrated Circuits (PICs), enabling the optimisation of back-end processes and cost reduction.

LioniX International
Develops and commercialises silicium-nitride (SiN)-based waveguide technology (TriPlex) for a variety of applications and is a leader in the photonic sector.

Nobleo Technology
Realisation of software for the automatic inspection of photonic chips (PICs).

Photonic Integration Technology Center (PITC)
Shortening the path to the commercial application of integrated photonics through application-driven technology programs and by offering access to shared infrastructure.

Salland Engineering
World-leading in test technology and engineering, specialised in solutions and services to improve efficiency and quality testing at semiconductor manufacturers.

Settels Savenije
Total solution supplier for high-tech equipment, systems, modules and critical components, including engineering and prototyping.

Technolution
Advanced electronics and embedded systems for complex instruments: specialist in the (combined) development of software, programmable logic and electronics for embedded and technical information systems

TNO
One of the focus areas in the TNO expertise centre for semicon and quantum is optical metrology. TNO 's goal is to bridge low TRL developments and businesses.

Workfloor
Development of software modules that interact with manufacturing execution systems.

High Tech NL Semiconductors
Fully focused on the vast and strong semicon industry and operates as a 'single point of contact' in all steps of the value chain. Drives and stimulates (international) cooperation and initiates and facilitates (international) innovation and crossover projects.

Berenschot
A consultancy company that supports High Tech NL with grant proposal writing and project management and facilitates cooperation between companies and the growth of ecosystems.