FLEXIT

The high volume production line for Integrated Photonics

Photonic integrated circuits (PICs) play an essential role in finding and developing solutions to many of the world's critical problems, such as reducing energy consumption, improving healthcare, fighting food waste and meeting our continuous hunger for information. However, a generic solution for the assembly and packaging of photonic chips does not currently exist. The FLEXIT project, which runs from January 2022 to December 2023, therefore sees an opportunity to unite high-tech companies in the Netherlands and push forward this highly promising domain.

The FLEXIT project will enable this through the further development of the FLEXIT method to process photonic chips at an industrial level. Through a design tool for product development and the mapping of the entire digital chain, the project will also optimise all production processes in the supply chain. Ultimately, two demo products will be selected to test the supply chain according to a new FLEXIT product standard for mass production, through which manufacturing yield will rise, costs will be reduced and delivery reliability can be maintained for the foreseeable future.

EUROPEAN UNION
European Regional Development Fund.
Funded as part of the Union's response to the COVID-19 pandemic

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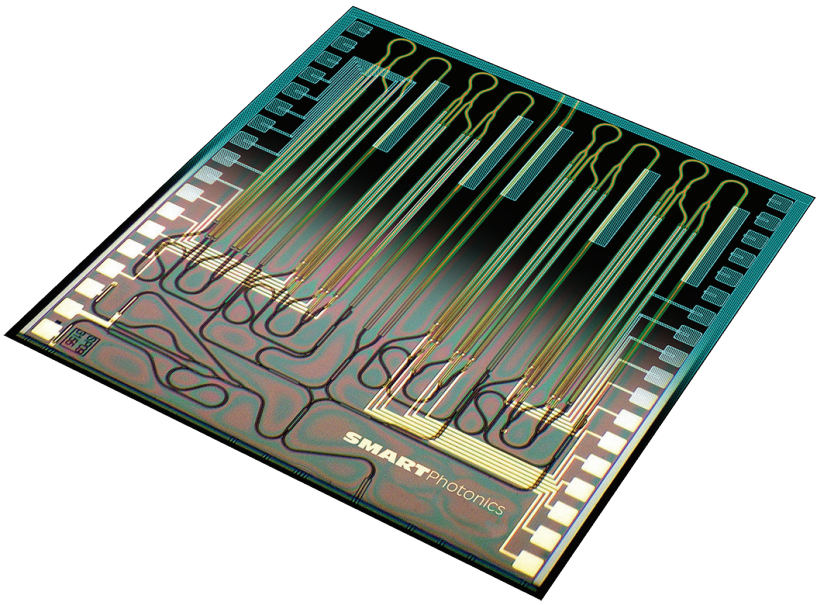
SMART Photonics pushes forward PICs in the FLEXIT project

As one of 11 partners in FLEXIT, SMART Photonics is an independent pure-play foundry which focuses on high-end PICs and offers solutions for data, telecommunication, sensing (such as Lidar) and medical applications. Involvement in the project is being carried out within the R&D team, headed by Ruud Vullers, while project leader Netsanet Tessema is coordinating her technical and administrative input together with her R&D colleagues. As the leading foundry for indium phosphide (InP) PICs, SMART Photonics offers FLEXIT many years of experience in producing active and passive building blocks within the same integration platform, thereby providing unique capabilities unparalleled by other InP foundries.



A unique device

Active elements generate, amplify or absorb light in response to an externally applied electric field. Typical active elements include amplifiers, detectors, lasers and modulators (like the recently developed high-speed modulators that allow transmission of multi-Gbps data rates for telecom and data centre applications). Passive elements – such as optical waveguides, multimode interference (MMI couplers) and (de)multiplexers – are used to transport the optical signal(s) in the PIC and to interconnect active elements. These components are integrated and fabricated onto a single substrate to create a uniquely compact and robust photonic device, significantly reducing space requirements and assembly costs. In addition, SMART Photonics is always striving to achieve improved quality and higher yield in the PIC manufacturing process via the development of new, innovative ideas. This is in line with FLEXIT's vision on the development of assembly processes for mass production.

Lock and key

To make this vision a reality, SMART Photonics' unique capabilities will be used to produce InP integrated chips equipped with facet structures: special structures on the chip that allow for direct on-wafer coupling of light into and out of the photonic chips. Standard chips

do not have these facet structures; it is therefore possible to connect light into and out of a PIC only after the complete fabrication of the wafer and upon the singulation of the individual dies. Instead, the use of facets will enable easier connection of the InP PIC to an external optical element and allow the PICs to be tested while they are still an integral part of the wafer, translating into significant reductions to testing time and costs.

Optical contacts to the facets are obtained through the use of 'finger structures' defined on silicon nitride (SiN) optical chips. Thanks to the special design of the facets and the fingers, a simple alignment procedure enables physical contact between the two PICs, allowing the optical beam to travel from the InP to the SiN or vice versa. FLEXIT's self-aligned assembly process enables Si3N4 fingers (analogous to a door key) to fit into position inside of InP facets (analogous to a lock). This leads to a low coupling loss of <0.5 dB/facet. This key-lock structure has two further advantages:

- The assembly between the InP and SiN can be performed with larger tolerances (± 2 um) than what is typically required (< ± 0.5 um).
- The fingers can serve as an optical probe for wafer-level testing, enabling the identification of functional dies very early in the process.

So far, SMART Photonics has developed a new process flow for the production of quality facets with high surface smoothness. The smooth surface of the facet provides a flat landing area to the flexible fingers, which is important to maintaining low optical coupling loss. In 2023, SMART Photonics will focus on the development of the overall assembly through work on two different applications: an initial production run which will host C-band lasers (1550 nm) and a second production run which will host O-band modulators (1310 nm). Within these, the facet structures will allow for hybrid integration with Si3N4 chips produced by LioniX, enabling the coupling of light between two integration platforms.

Securing the future

As the assembly process for photonic chips is currently four times as expensive as the cost of the chip itself, market penetration has been significantly limited. The main value within the FLEXIT project will thus be the improved assembly technique based on InP facets and Si3N4 flexible fingers, through which the expensive, time-consuming alignment technique will no longer be needed. At the same time, the project will demonstrate the feasibility of an innovative on-wafer optical testing method, enabling the easier selection of known, good-quality dies in the future. The Si3N4 optical probes will be used to couple light into and out of InP wafers. This selection process avoids the expensive die-level testing that typically happens during the post-production of wafers.

In the near future, SMART Photonics would like to see successful prototypes that prove the feasibility of the new assembly process, enabling optical contact between InP facets and Si3N4 fingers. Following the demonstration of FLEXIT prototypes, new market possibilities are expected to arise for both SMART Photonics and the entire Dutch supply chain for the mass production of photonic components. In time, this will allow the Netherlands to become the international production centre for high-volume photonic manufacturing equipment in the face of enormous global demand.

FLEXIT project partners

Chilas
Development and production of semiconductor lasers based on several materials with high power in combination with integrated technology.

IMS
Development of production and assembly lines for hybrid microsystems with added value like lenses for smart phones, medical implants and microsystems.

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

PHIX
World-leading packaging and assembly foundry for Photonic Integrated Circuits (PICs), building optoelectronic modules based on all major PIC technology platforms in scalable manufacturing volumes.

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

SMART Photonics
The first "pure-play foundry" in the area of InP PIC production and on the verge of scale up.

Synopsys
Supports the project with design software and tools for the development of photonic ICs.

VTEC
Development and realisation of lasers and sensors for various photonic platforms. Assembly and packaging is taken care of including fibre connections.

Workfloor
Supplier of factory data collection systems.

High Tech NL
The national branch association for the Dutch high-tech industry. Its Semiconductors cluster is fully focused on the vast and strong semicon industry, operating as a 'single point of contact' in all steps of the value chain, driving and stimulating (international) cooperation, and initiating and facilitating (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.