Fraunhofer IPMS

Integrated Photonics

Devices and Technologies

A wide range of markets benefit from integrated photonic solutions that combine electronics, photonics, passive optics, and other technologies into miniaturized systems using various integration techniques. In addition to the exponential growth of data centers – particularly for AI applications – new areas of application across numerous industries are increasingly driving the advancement of integrated photonics.
The transition from electrical to optical communication and data processing reduces enormous energy consumption while simultaneously creating a powerful foundation for novel applications. Fraunhofer IPMS develops photonic components and scalable manufacturing capacities to comprehensively serve these established and emerging markets with application-specific solutions.

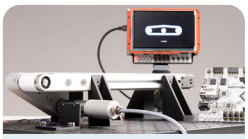
Applications



Data Centers (especially in AI applications)



Optical Communication & Data Processing



Sensors & Automation



Telecommunications



Medical Technology & Health



Mobility & Space



Security



Optical AI & Quantum Computers

APECS

Contact

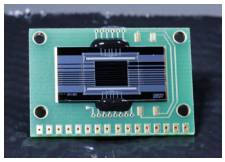
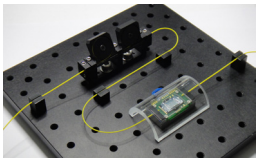
Jörg Amelung
Division Director Engineering, Manufacturing & Test
+49 351 8823-4691
joerg.amelung@ipms.fraunhofer.de

Fraunhofer IPMS
Maria-Reiche-Strasse 2
01109 Dresden, Germany
www.ipms.fraunhofer.de/en

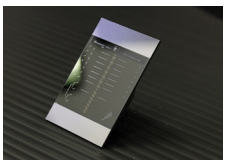
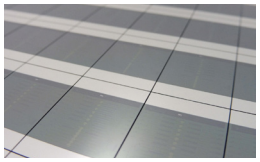
Integrated Photonic Devices

Fraunhofer IPMS offers a broad portfolio of technological solutions that, in collaboration with industry partners, have led to a wide variety of integrated photonics devices:

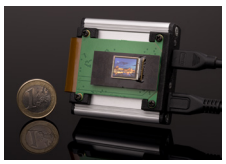
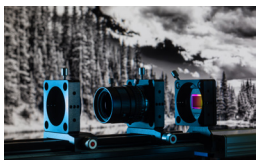
- **Integrated waveguides based on silicon nitride technology (200 mm and 300 mm)**
  Application: All-optical switches and (de-)multiplexers for telecommunications
  Advantage: The combination of silicon nitride and liquid crystal waveguides enables programmable photonic devices that can be flexibly adapted to the application.

- **Photonic biosensors based on microring resonators and Mach-Zehnder interferometers (silicon nitride technology)**
  Application: Biomedical diagnostics
  Advantage: Compact, scalable sensor technology for fast, sensitive, and label-free multiplex analyses – cost-effective thanks to regenerable chips and flexible biofunctionalization.

- **OLED-on-silicon devices, primarily for OLED microdisplays and optoelectronic sensors**
  Applications: AR/VR for medical technology, industry, and security
  Advantage: OLED-on-silicon solutions combine optical and electronic functions on a single chip – enabling compact, high-performance, and scalable photonic systems.

Fraunhofer IPMS has developed a universal manufacturing technology called MEMS-on-PIC for photonic integrated circuits (PICs) with MEMS structures.

- For all established materials such as silicon, silicon nitride, and lithium niobate
- MEMS structures are fabricated directly on the waveguide plane of existing PICs without compromising their optical properties
- The central element is optical MEMS phase shifters, which form the basis for photonic processors

Quasi-Monolithic Integration for Photonics

The integration of photonic and electronic functions is complicated by differences in substrate materials, limited manufacturing yields, and high packaging costs.

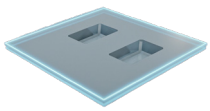
The QMI technology developed by Fraunhofer IPMS as part of the European APECS pilot line overcomes these limitations through the precise integration of photonic and electronic chiplets into patterned silicon wafers ("pockets").
The subsequent back-end-of-line bonding enables both electrical and optical connections to the chiplets.

In this way, QMI combines the flexibility of heterogeneous integration with the high integration density of monolithic approaches – CMOS-compatible and utilizing existing 200 mm and 300 mm wafer fabs. This technology opens up new possibilities for highly integrated photonic systems, including co-packaged optics.

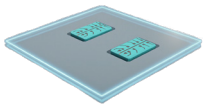
This results in the following benefits:

- **Higher performance:** Shorter signal paths reduce losses and latency and increase processing speed at the system level.
- **Lower optical losses** due to high-precision positioning.
- **Reliability:** The reduction in mechanical interfaces increases robustness and service life.
- **Compactness:** Quasi-monolithic integration saves a significant amount of space because the elements are integrated in a nearly monolithic manner.
- **Cost-effectiveness:** The combination of modular chiplet approaches enables highly cost-effective integration while ensuring short innovation cycles and high scalability.

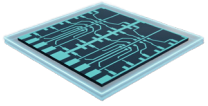
Fraunhofer IPMS offers QMI technology both for joint customer projects aimed at developing application-specific integrated photonics devices and for foundry services.



1. Structured wafer
Silicon wafer with pockets in the size of the chiplets.



2. Integration of Chiplets
Photonic and electronic chiplets are integrated.



3. Optical and Electrical Connections
Bonding connects the chiplets to form a system.