APECS

Coordinated by

Fraunhofer

Implemented by

Forschungsfabrik Mikroelektronik Deutschland

Heterogeneous integration and QMI in APECS

Utilizing chiplets for heterogeneous integration in semiconductor manufacturing enables the development of specialized electro-optical systems on a single platform, addressing the challenges of cost and complexity associated with traditional IC production.

The increasingly higher costs for further node miniaturization in the IC manufacturing process will promote the interconnection of so-called chiplets. The increasing miniaturization of semiconductor structures and the associated increase in technology complexity have led to an enormous increase in the cost of IC production. The idea now is to use different types of IPs that can be used for specific functions. Starting with solutions in the microprocessor sector, chiplet integration technology also offers new opportunities for innovation in the areas of MEMS, RF and optical systems. However, advanced heterogeneous integration is therefore essential for the integration of such chiplets, which goes far beyond the known integration methods for monolithic processes, such as full-chip integration and 2.5D integration. These concepts must be further developed in line with the qualitative and quantitative changes in industry requirements.

Heterogenous integration for Photonics and RF electronics

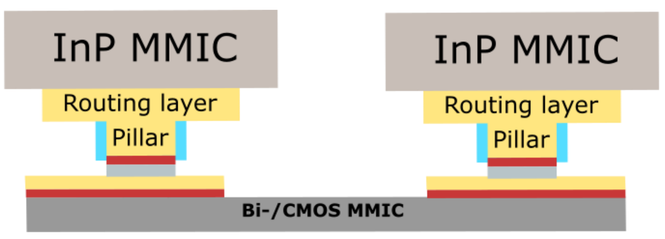
With Chiplets replacing sub-systems as building blocks for more complex system concepts, heterogeneous integration allows for photonic and electronic integration previously only feasible on board or “PCB” level. Examples for this are currently:

- Integration of Lasers and electronic drivers
- Photonic components with their passive waveguide platforms PICs
- Heterogeneous integration allows for integrating different material systems with combination of III-V MMIC processes and Si BiCMOS and CMOS as an example for achieving high-performance RF systems for frequencies beyond 100 GHz.

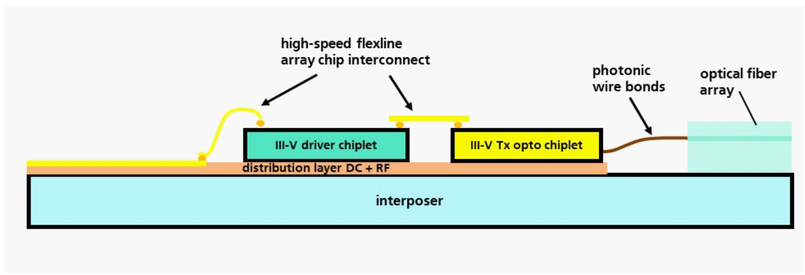
QMI for multiplatform integration

Quasi monolithic integration “QMI” is the next stage of heterogeneous integration of multiple technologies on a single platform. QMI aims at:

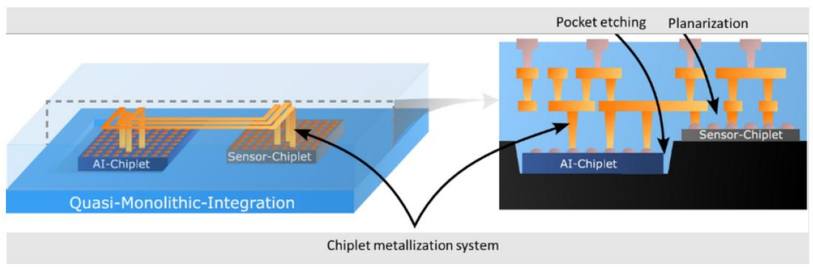
- Develop and implement a novel integration scheme for electro-optical chiplets, optimizing optical and photonic functionalities on CMOS wafers.
- Contribute to the APECS pilot line by finalizing results in a "backend optic design manual" and manufacturing passive chiplets with newly developed interfaces in collaboration with APECS partners.



Example of heterointegration in RF application



Electro-optic heterointegration with functional interposers



MEMS Chiplet as QMI solution

Process and Services

- Offer services to APECS pilot line and Partners
- Offer design area in MPWs and further formats
- Development of tailored integration solutions for RTOs and industry
- Support for innovative design solutions for heterogeneous integration

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RF heterogeneous integration of InP on BiCMOS Chips
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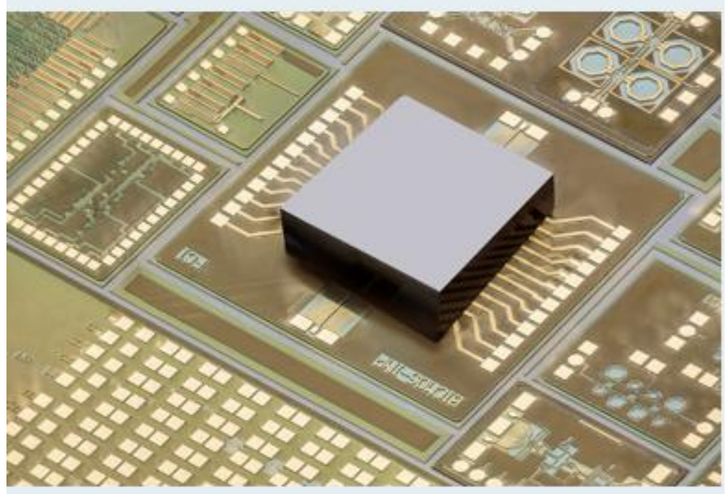

QMI Pocket Fabrication process
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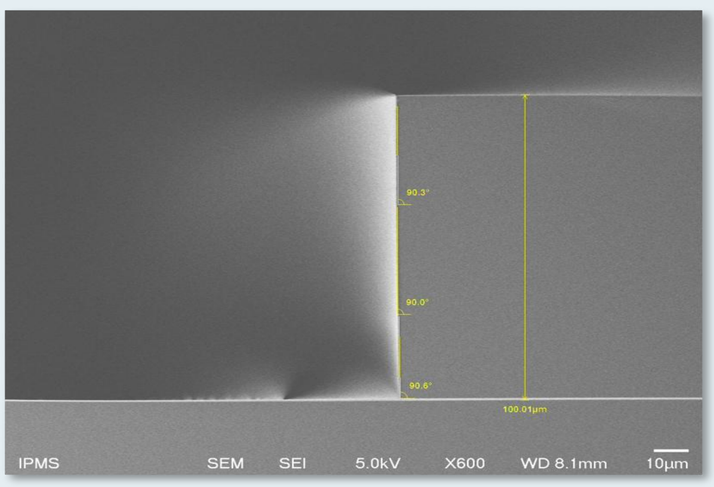
Lorenz, et al. „Quasi-Monolithic Integration (QMI) Enables New Possibilities for Sensor and MEMS Applications“, 2025



Additional information

The APECS consortium brings together the technological competences, infrastructure, and know-how of ten partners from eight European countries:
Germany (Fraunhofer-Gesellschaft as coordinator, FBH, IHP), France (CEA-Leti), Belgium (imec), Finland (VTT), Austria (TU Graz), Greece (FORTH), Spain (IMB-CNM, CSIC) and Portugal (INL).

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