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Neuromorphic Photonic-Electronic Microprocessors

Scalable InP-Laser Chiplets for Neuromorphic Computing (SILC-NC)

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1 Photonic Neuromorphic Processing

State of the art:

- Neuromorphic information processors execute specific tasks significantly faster and with much lower energy consumption than current CPU/GPU based computers
- Neuromorphic components have been demonstrated in photonic platforms benefitting from the higher operation frequency and information bandwidth of this technologies.

Challenges towards scalable photonic solutions:

- Silicon Photonics enable high integration densities and reliable fabrication platforms, but lack efficient light sources
- Laser sources on Indium Phosphide platform with light transfer via edge-coupling with coupling efficiency of 33% and power of 2 mW (TRL 1)
- Integration with Silicon waveguides requires time-intensive active alignment to minimize photonic losses

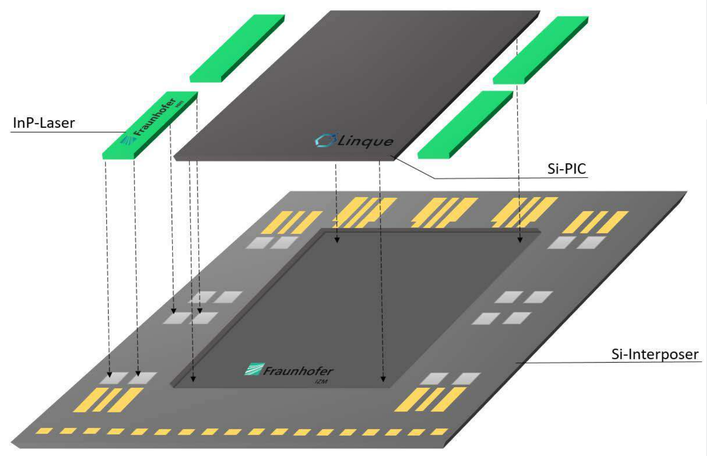
2 Innovation

Heterogeneous integration for photonic neuromorphic processors

- On-Chip integration of Indium Phosphide (InP) DFB laser with Silicon-Photonic circuits
- Realization of Leaky Integrate-and-fire (LIF) neurons within this heterogeneous photonic platform for high spike-rates and low latency

Our Solution:

- Develop flip-chip compatible InP-lasers and specialized Silicon photonic integrated circuits (Si-PIC)
- Passive packaging concept based on a high-precision silicon interposer
- Edge-to-edge optical coupling and on-chip metal wires for low photonic losses and low latency electrical connections



Heterogeneously integrated InP-Laser with Silicon Photonic Integrated circuit

3 Future performance profile & skills of the project partners

LMU Munich & Linque

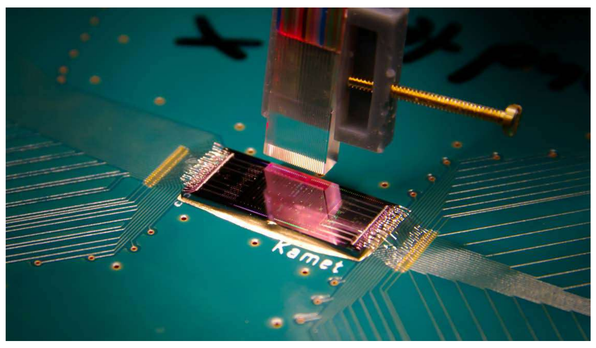
- Focus on hybrid photonic-electronic integrated circuits for information processing
- Innovative novel integrated circuit relies on using light as the information carrier and processor

Fraunhofer HHI

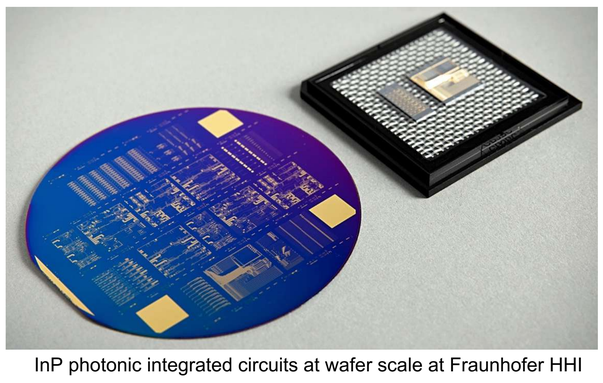
- Expertise in InP-based discrete and PIC devices, as well as TFLN- and polymer based PLCs and hybrid PICs
- Develops various high-end InP-based photonic devices in collaboration with SMEs

Fraunhofer IZM

- Specialized on packaging technology and integration of chiplets into systems
- Expertise in simulations, electro-optical characterization and 3D system-in-package solutions with optical layers



Picture of current photonic microprocessor at LMU


InP photonic integrated circuits at wafer scale at Fraunhofer HHI

4 Prospects

Efficient integration of high-power laser sources with optical on-chip waveguides

- Develop specific flip-chip compatible InP chiplets with high-power (>100 mW) DFB lasers as coherent light source for photonic microprocessors
- Demonstrate wafer-scale heterogeneous integration of indium phosphide and silicon photonic integrated circuits
- Realize LIF neurons interconnected by optical waveguides in photonic integrated circuits for high-speed neuromorphic processors
- Commercialize and deploy energy-efficient information processing in optical domain based on chiplet approach

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