moduleqnc
quantum & neuromorphic computing

Core technologies behind neuromorphic photonics

Neuromorphic integrated circuits (PICs) and systems

1 State-of-the-Art

Latest advancements on neuromorphic PICs

Neuromorphic PICs contribute to the development of high-speed, energy-efficient computer hardware systems using NNs. They address scaling challenges such as data processing bottlenecks and power consumption, enabling more complex and efficient signal processing.

2 Underlying principles

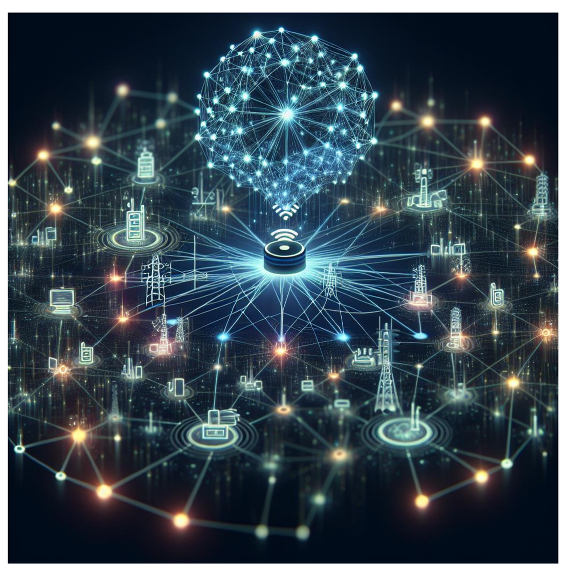
Integration of Passive and Active Photonic Components

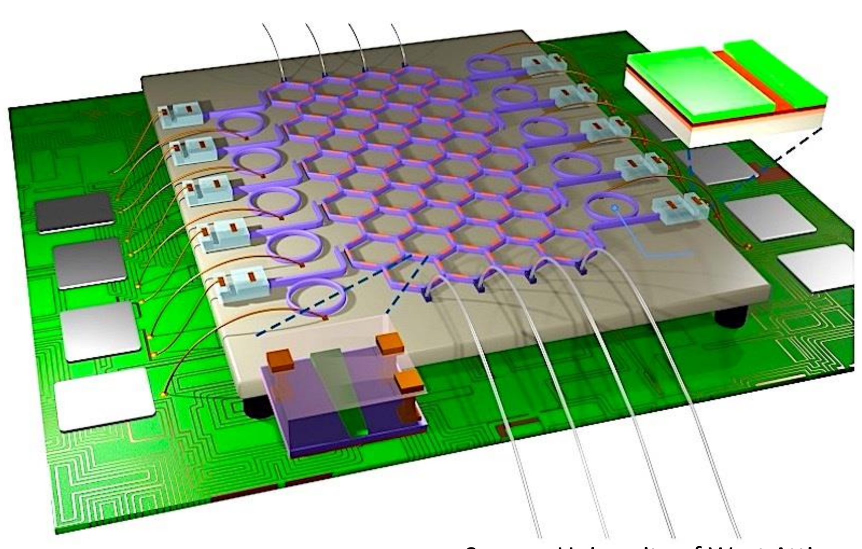
Neuromorphic PICs leverage the physical properties of different materials to perform complex computations. Passive components manipulate light without adding energy, while active components like SOAs amplify signals and introduce nonlinearity, essential for neural network operations.

3 High-speed, scalable, energy efficient systems

Specifications, important & unique selling points:

- **Ultra-fast processing:** Operations at the speed of light reduce latency.
- **Energy efficiency:** Lower power consumption compared to electronic systems.
- **Scalability:** Dense integration of photonic components on chips.
- **Versatility:** Hybrid-PICs enable complex neuromorphic architectures by combining passive and active elements.





Source: University of West Attica

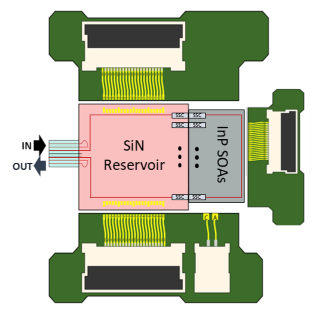
4 Enabling technologies

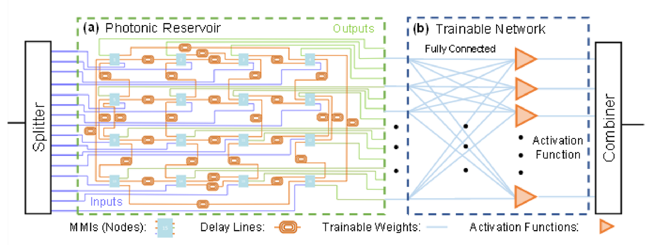
Silicon-on-Insulator (SOI) and Silicon Nitride (SiNx) PICs

SOI and SiNx technologies allow for the creation of passive photonic components like **photonic reservoirs** and **Mach-Zehnder Interferometer (MZI) meshes**. These components are crucial for implementing linear optical processors and extracting temporal interdependencies in optical signals.

Indium Phosphide (InP) PICs and Hybrid Integration

InP PICs enable active components such as **Semiconductor Optical Amplifiers (SOAs)**, which function as photonic activation functions due to their nonlinear response. **Hybrid-PICs** combine SOI, SiNx, and InP technologies, integrating passive and active components within a single package.





5 Summary

Neuromorphic photonic integrated circuits and systems are revolutionizing NN hardware development. By harnessing SOI, SiNx, and InP technologies, they offer faster, more efficient processing capabilities, addressing critical scaling challenges and paving the way for advanced applications.

6 Outlook

Significant investments are being made in developing these PICs, highlighting their crucial role in the future of AI. Ongoing research focuses on improving integration techniques, exploring new materials, and enhancing the capabilities of neuromorphic photonic systems to meet the growing demands of AI technologies.

For inquiries, email us at experts@module-qnc.de

SPONSORED BY THE
Federal Ministry of Education and Research