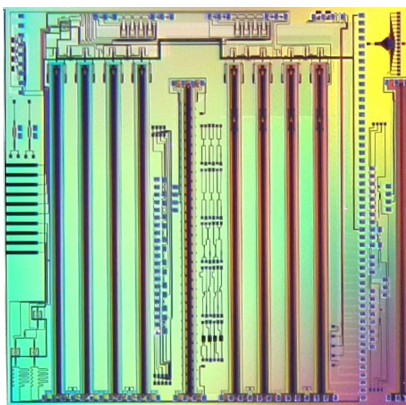
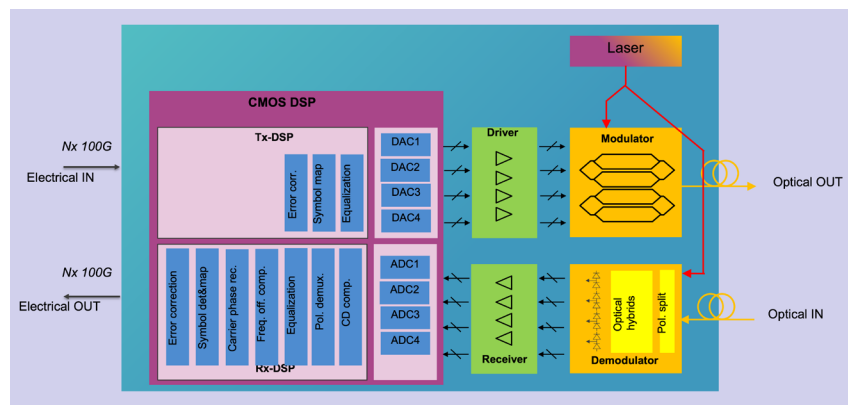


# Photonic and electronic ICs for high-speed wireline transceivers

With the exploding data-rate needs of current and future digital applications, ever higher requirements are being set on the wireline transceivers for inter- and intra-data-center traffic. The focus is on increasing the capacity of these optical transceivers, while simultaneously increasing the integration density and energy efficiency with each new generation. Imec takes on this double challenge by developing high-speed electronic and photonic integrated circuits for 100-130Gbaud and future 200Gbaud transceivers.



Prototype Silicon Photonic IC



Optical transceiver building blocks

## 100 to 130Gbaud transceivers

- Photonic and electronic ICs for IMDD and coherent optical transceivers
- Requires 50-60GHz optoelectronic front-end bandwidth
- Several silicon photonic platforms for modulating, detecting and passive devices
- Demonstration of electro-absorption modulators (O-band)

## Beyond 200Gbaud transceivers

- Indium phosphate or  $\text{LiNbO}_3$  integration onto SiPhotonic or SiN platform
- CMOS-compatible BTO-based modulators, integrated in 200mm platform
- Shift functionality of electronics further into the optical domain. Demonstrated by optical equalizer.

## Enabling technologies

### Silicon photonic building blocks for coherent transceivers

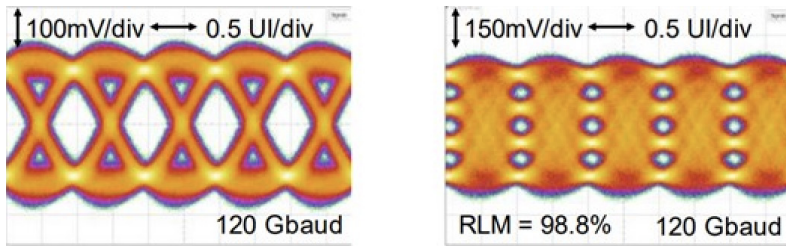
- O-band and C-band dual-polarization IQ modulators: variants possible with and without built-in optical equalizer to trade bandwidth for drive voltage
- Polarization beam splitters/rotators/combiners
- Various optical hybrid alternatives covering O-band or C-band

### SiGe BiCMOS analog front-end electronics

Advantages: better compatibility with high drive voltages and broadband operation

Available silicon design IP and prototype samples:

- 4-channel linear Mach-Zehnder modulator driver array with 90GHz bandwidth
- 4-channel linear transimpedance amplifier array with 60GHz bandwidth
- Various analog and PAM-4 capable multiplexer chips up to 120Gbaud PAM-4



120Gb/s NRZ eye diagram (left), 240Gb/s PAM-4 eye diagram (right), generated with PAM-4 MUX



4-channel transimpedance amplifier (left), 4-channel Mach-Zehnder driver (right)

### Ultra high-speed ADCs and DACs using highly scaled FinFET CMOS

- 5- and 3nm technologies for ultra-high-speed ADCs and DACs
- Focus is on lower power consumption and smaller area
- Design of 5nm ADC and DAC prototypes ongoing
- Research towards low-power digital domain CDR for >100Gbaud PAM-4 on-going

### Heterogeneous integration

To further extend the functionality of SiPhotonic and SiN platforms with e.g. lasers, optical amplifiers, closely integrated high-speed electronics, heterogeneous integration is essential. Different approaches are pursued at imec, some examples are:

- Ultra-high precision alignment flip-chip processes to integrate InP optical amplifiers and lasers on SiPhotonic wafers. Alignment accuracy better than 500nm and >10mW waveguide coupled laser power have been demonstrated.
- Micro-transfer printing: leveraging MEMS-etch techniques, this approach allows depositing thousands of devices in a single step. Research towards integration of various materials (InP, GaAs quantum dot regions, LiNbO<sub>3</sub>, InP) using this approach is on-going under the framework of various EU projects such as Caladan.

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