Concept, design and verification of components for an integrated on-detector silicon photonic multi-channel transmitter unit

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Motivation

The data throughput of future detector readout systems is ever increasing. To satisfy the requirements of ultra-broad bandwidth, we propose a high-performance optical link utilizing wavelength-division multiplexing (WDM). The key components are monolithically integrated silicon photonic transmitter units, each with four parallel channels. With more parallel channels and more advanced modulation format, the bandwidth could achieve several Tbit/s potentially.

Multimode interferometers

Waveoptic simulation with COMSOL.

Simulated power ratio of output channels versus input wavelength, max. 0.6 dB loss in total.

Electro-optic modulators

The phase shift of an individual pn diode phase shifter versus the bias voltage for different shifter lengths.

Thermal modulators

Normalized transmission versus input electrical power.

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Eye diagram of one channel from a 4-channel integrated WDM transmitter unit at a bit rate of 5.65 Gbit/s. Measured bit error rate (BER) of 1.7 × 10⁻⁶ over 45 minutes.

Outlook

- Downlinks with monolithically integrated Ge-photodiodes
- Dynamically reconfigurable Rx and Tx channels
- Advanced modulation formats for higher bandwidth
- Working point control
- Monolithic integration of sensors, ASICs, and photonics

Ultra-fast detector readout system for particle physics and photon science.

(System Schematic)

(De-) Multiplexers

The transmission spectrum of a 1 × 9 demultiplexer of an on-chip integrated WDM transmitter unit.

Waveoptic simulation with COMSOL.

Photonic system chip (9.2 × 9.2 mm²) with 4-channel WDM transmitter units, individual pn-modulators, thermal modulators, Echelle grating (de-) multiplexers, and test structures.