

Silicon Photonic High-Speed Data Transmission System for Detector Instrumentation

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Introduction

- Millions of channels in future detector systems
- Read-out is the bottleneck of data acquisition
- Raw data rate is advancing towards hundreds of Tbit/s and beyond

Detector operating conditions

- Low temperatures (> -25 °C)
- Magnetic field (1...4 Tesla)
- Radiation exposure

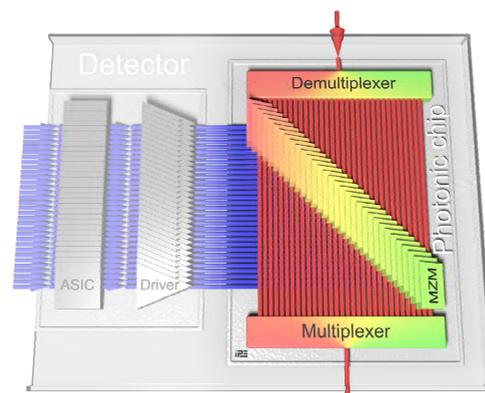
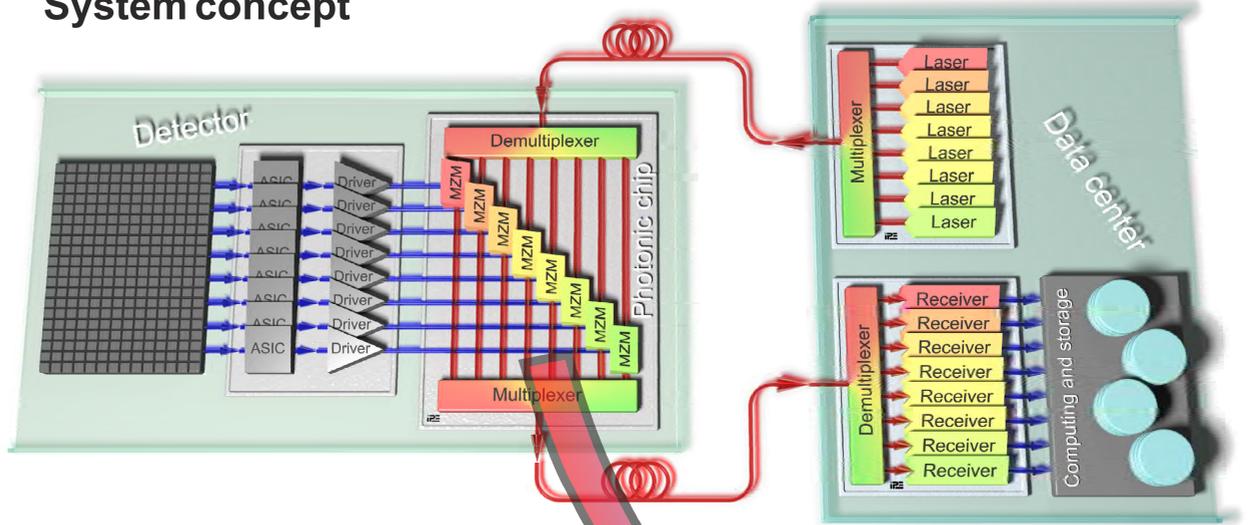
Vision

- Optical data transmission system based on **wavelength division multiplexing (WDM)**
- **Monolithically integrated** Mach-Zehnder modulators and optical (de-)multiplexers
- **Lasers** located off-detector
- **Demonstrator:** 160 Gbit/s per fiber, possible upgrade to 640 Gbit/s
- Future system with 64 channels up to **5 Tbit/s**

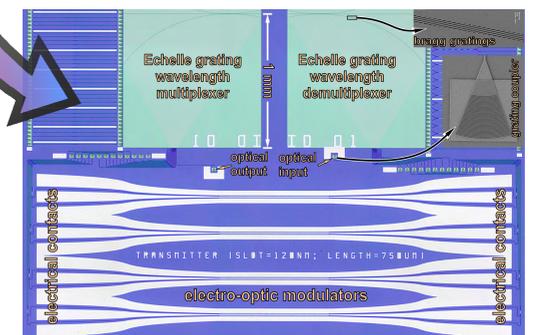
Intensity modulators

- Plasma-dispersion effect: modulation of free charge carrier concentration governs refractive index of pn-junction
- MZI-structure translates phase variation into intensity modulation
- Bandwidth: 18 GHz, extinction ratio: 13 dB

System concept



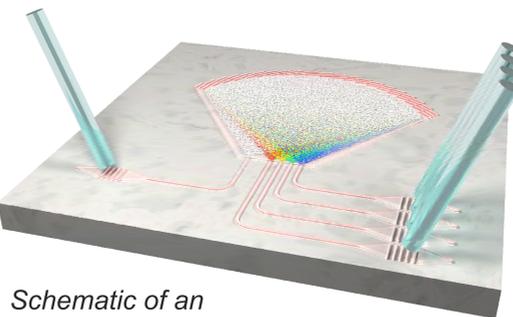
64-channel system for a data rate of up to 5 Tbit/s



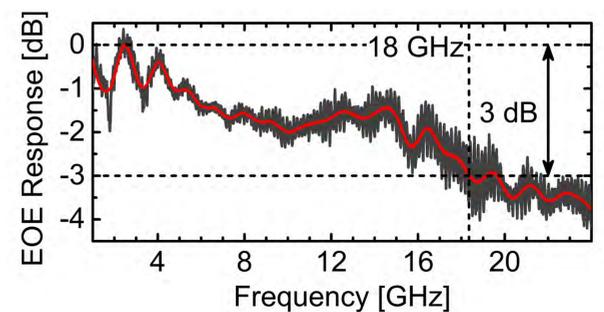
Monolithically integrated WDM transmitter (design KIT/IPE, fabrication IMS CHIPS)

Wavelength multiplexers

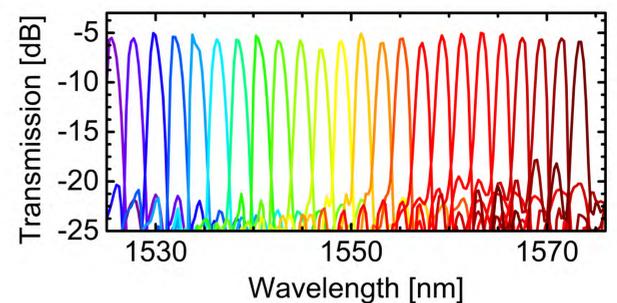
- Echelle grating: curved diffraction grating in film waveguide routes channels to individual output ports according to their wavelength
- 45 channels on an area of 0.5 mm²
- 5 dB on-chip loss and -16 dB average adjacent-channel crosstalk



Schematic of an echelle grating multiplexer



Electric-optic-electric frequency response of pn-modulator (OpSIS)



Segment of transmission spectrum of a 45-channel echelle multiplexer (design KIT/IPE, fabrication IMS CHIPS)

Conclusion

- Electro-optic pn-modulators demonstrated with a bandwidth of **18 GHz**
- Wavelength division (de-)multiplexer with **45 channels** designed and fabricated
- **5 Tbit/s** silicon photonic WDM systems seem feasible using a **64 channel transmitter**