Contribution ID: **363** Type: **Poster**

Silicon Photonic Devices for Optical Data Readout in High-Energy Physics Detectors

Friday, 27 May 2022 15:42 (1 minute)

Optical transceivers have rapidly become essential components in the readout sub-systems of high-energy physics (HEP) experiments. Given the ever-increasing radiation hardness requirements for next-generation colliders, existing readout systems based on directly modulated laser diodes, e.g., VTRx+, will rapidly become ineffective [1]. Properly engineered silicon-based photonic modulators have been shown to sustain higher radiation tolerance than current VCSEL-based devices [2]. In addition, silicon photonics (SiPh) solutions could enable higher data rates and lower power consumption with further possibilities of data aggregation, e.g., wavelength division multiplexing (WDM).
A full-custom photonic integrated circuit (PIC) in IMEC's iSiPP50G silicon-on-insulator (SOI) technology has been designed in the context of the INFN-funded projects PHOS4BRAIN and FALAPHEL to further explore SiPh suitability for radiation-pervaded use cases. The latter project indeed aims to the development of a radiation-tolerant 4-lane SiPh WDM transmitter driven by custom-designed electronic integrated circuits (EICs) to implement an aggregated 100 Gb/s transmission bandwidth.
The PIC includes different flavors of SiPh optical modulators (Mach-Zehnder, ring or silicon-germanium electro-absorption modulators) to understand those which may best fit as building blocks in a future radiation-hard integrated optoelectronic readout module. This contribution will present recent developments and preliminary device characterizations of the SiPh modulators designed to target total ionizing doses (TIDs) up to 1 Grad.

References
[1] J. Troska, et al., "The VTRx+, an Optical Link Module for Data Transmission at HL-LHC", Topical Workshop on Electronics for Particle Physics (TWEPP-17), doi: https://doi.org/10.22323/1.313.0048
[2] M. Zeiler et al., "Radiation Damage in Silicon Photonic Mach–Zehnder Modulators and Photodiodes," in IEEE Transactions on Nuclear Science, vol. 64, no. 11, pp. 2794-2801, Nov. 2017, doi: https://doi.org/10.1109/TNS.2017.2754948

Collaboration

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Session Classification: Front End, Trigger, DAQ and Data Mangement - Poster session