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Developments on Radiation-Hard Silicon Photonic Devices towards Integrated Transmitters for High Energy Physics

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Custom silicon photonics intensity modulators for data readout in particle detectors will be presented together with preliminary experimental results. A variety of devices has been designed to explore the technological requirements to achieve data rate up to 25 Gb/s while sustaining extremely high dose levels (1 Grad total ionizing dose). Packaging constraints have been carefully considered to allow hybrid integration between photonic components, radio-frequency boards and integrated electronics.

Summary (500 words)

Silicon photonics (SiPh) is progressively being evaluated as a potential technology to upgrade the optical transceivers deployed inside particle detectors. Compared to state-of-the-art readout systems based on directly modulated laser diodes, e.g., VTRx+ [1], SiPh solutions could enable higher data rates, possibilities of data aggregation (e.g., wavelength division multiplexing), lower power consumption and reduced material budget. Results from work recently carried out at CERN show a promising radiation hardness for SiPh devices which paves the way for unprecedented levels of integration with electronics and front-end modules [2].
According to those studies, we designed a silicon photonic integrated circuit (PIC) in Imec's iSiPP50G 220-nm silicon on insulator (SOI) platform. The PIC integrates a variety of optical modulators to further investigate their radiation tolerance and their interconnection with driving electronics. Those modulators would be the building blocks to create a full integrated system.
Targeting a challenging 1 Grad total ionizing dose (TID) tolerance, some custom shallow-etched Mach Zehnder modulators (MZMs) have been designed with different doping configurations to understand the trade-off between radiation hardness, optical losses, and modulation efficiency. Each MZM is equipped with traveling-wave (TW) electrodes to study the influence of the pn junction loading and the radiation effects on the microwave response of the device.
All the components are laid out to guarantee both chip probing as well as hybrid packaging with radiofrequency printed circuit boards (RF-PCB) and integrated driving electronics. The flexibility allowed by this design enables high speed characterizations both in laboratory as well as inside irradiation chambers.
Ultra-compact meandered MZMs have also been designed to provide power-efficient alternatives to conventional TW devices. A footprint reduction generally extends the electro-optic modulation bandwidth and exempts from the usage of a terminating impedance, reducing power consumption and limiting on-chip thermal dissipations.
In addition, some building blocks for SiGe electro-absorption modulators (EAMs) have also been included to test their suitability under irradiation. To the authors'knowledge this would be the first time that such modulators are tested for HEP purposes. Given the radiation tolerance demonstrated by CERN for germanium (Ge) integrated photodetectors [3], it is likely that also those SiGe devices would present similar performances and thus add more design choices for future SiPh-based transceivers to be operated in harsh radiation environments.
The PIC was submitted for production in June 2020 and it is expected to be delivered in July 2021. According to this schedule, we expect to have some preliminary measurement results by the start of TWEPP conference in 2021.

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
[3] A. Kraxner, et al., "Radiation tolerance enhancement of silicon photonics for HEP applications", Topical Workshop on Electronics for Particle Physics (TWEPP-18), doi: https://doi.org/10.22323/1.343.0150

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