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Total Ionizing Dose Testing of Radiation-Hardened Silicon Photonic Mach-Zehnder Modulators

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Silicon photonics (SiPh) technologies have started to be evaluated to assist the evolution of the electro-optical transceivers (TRXs) deployed inside data readout links in high-energy physics (HEP) experiments. Preliminary results indicate that SiPh circuits can effectively operate in environments with high levels of both ionizing and non-ionizing radiation [1,2]. In the recent years, focused research activities have aimed to combine the proven capabilities of high-speed and power-efficient communication inherent in SiPh solutions with the extreme radiation tolerance requirements of HEP environments. The development of fully-integrated SiPh-based TRXs thus necessitates radiation-hard modulating devices. However, these components must also meet appropriate performance levels to align with the optical and electrical power budgets of HEP communication links, which strongly depend on the actual modulator design.

At the core of all-silicon integrated high-speed photonic modulators are PN junction-based phase shifters. These PN junctions, embedded in integrated waveguides to transfer electrical modulation to optical waves, have been found to be extremely sensitive to ionizing radiation exposure. However, by acting on design parameters such as dopant concentration and optical waveguide geometry, radiation hardness in compliance with the innermost detector layers of HL-LHC experiments has been achieved also for these SiPh devices [1,2]. Unfortunately, these parameters are directly linked to nominal component performances, including modulation efficiency or optical propagation losses, which may, in turn, be adversely affected by radiation [3]. Henceforth, a design trade-off must be achieved to operate these devices in the optimal way.

Several Mach-Zehnder modulators (MZMs), designed in the context of INFN's FALAPHEL project with different phase shifting cross-sections, will be presented to thoroughly explore the design space of radiation-hard-by-design (RHBD) PN junction-based modulators. This contribution will present the impact of radiation hardening techniques on device performance metrics.

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Collaboration

Role of Submitter

I am the presenter

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