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Thin silicon sensors for extreme fluences: a doping compensation strategy

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Future hadronic colliders, like FCC-hh, demand efficient tracking detectors in environments with expected fluences exceeding 1×10^{17} 1MeV $n_{eq}cm^{-2}$.
Thin Low-Gain Avalanche Diodes (LGADs) emerge as promising candidates for 4D tracking in upcoming experiments, exhibiting precision in timing and tracking capabilities. Their internal signal amplification proves effective in mitigating radiation damage effects (e.g., charge collection efficiency loss) up to approximately 3×10^{15} $n_{eq}cm^{-2}$. A significant performance deterioration has been observed above 5×10^{15} $n_{eq}cm^{-2}$, when the acceptor removal effect completely neutralizes the charge multiplication mechanism.
Within this framework, the CompleX project aims at extending the operation range of silicon detectors as 4D trackers up to 5×10^{17} $n_{eq}cm^{-2}$. The project envisions achieving this unprecedented radiation tolerance through a novel comprehension of radiation damage saturation and an innovative design for the LGAD gain layer with compensated implants. In compensated design, the gain layer results from overlapping p+ and n+ implants: the effective doping concentration will be similar to standard LGADs. Both acceptor and donor atoms will undergo removal with irradiation, but if properly engineered, their difference remains constant even with irradiation, ensuring enhanced radiation resilience. Applying these breakthroughs to thin LGAD sensors (20–40 µm) with an internal gain of 10-20, enables the design of innovative silicon sensors operating efficiently up to the target fluence.
Understanding and modeling the radiation damage effects up to 5×10^{17} $n_{eq}cm^{-2}$ has the utmost importance, and state-of-the-art Technology CAD tools will be used for the purpose at hand. Numerical modeling strategies for extreme fluences will be presented. Measurements and signal analysis of the first production of compensated LGADs (FBK foundry's release in late 2022) before and after neutrons irradiation, will be presented and discussed and future design evolution for compensated LGADs will be envisaged.

Collaboration

Role of Submitter

I am the presenter

Primary authors: MOROZZI, Arianna (INFN - Perugia); PATERNOSTER, Giovanni (Fondazione Bruno Kessler); ARCIDIACONO, Roberta (Istituto Nazionale di Fisica Nucleare); BORGHI, Giacomo (Istituto Nazionale di Fisica Nucleare); BOSCARDIN, Maurizio (Fondazione Bruno Kessler, Center for Sensors and Devices, Trento, Italy); CARTIGLIA, Nicolo' (Istituto Nazionale di Fisica Nucleare); CENTIS VIGNALI, Matteo (Fondazione Bruno Kessler, Center for Sensors and Devices, Trento, Italy); CROCI, Tommaso (Istituto Nazionale di Fisica Nucleare); FERRERO, Marco (Istituto Nazionale di Fisica Nucleare); FONDACCI, Alessandro (IOM-CNR / INFN Perugia); LANTERI, Leonardo (INFN - Torino); MENZIO, Luca (Istituto Nazionale di Fisica Nucleare); MOSCATELLI, Francesco (Istituto Nazionale di Fisica Nucleare); MULARGIA, Roberto (Istituto Nazionale di Fisica Nucleare); PASSERI, Daniele (University and INFN Perugia); SIVIERO, Federico (Istituto Nazionale di Fisica Nucleare); WHITE, Robert Stephen (INFN - Torino); SOLA, Valentina (Università degli Studi di Torino & INFN, sezione di Torino)

Presenter: MOROZZI, Arianna (INFN - Perugia)

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