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Determination of the proton related damage on commercial and high-ohmic silicon pad diodes

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Radiation hardness of detector sensors and components is a major challenge for the success of the scheduled High Luminosity upgrade of the CERN Large Hadron Collider, and a world-wide campaign for sensor characterisation and qualification has been undertaken. By convention, effects of irradiation with beams of different particle species and energy, aiming to assess displacement damage in semiconductor devices, are communicated in terms of the equivalent 1 MeV neutron fluence, using the hardness factor for the conversion. These hardness factors are subject to significant uncertainties, that complicate interfacility comparison.
Recently, the hardness factors for protons at three different kinetic energies have been estimated by analysing the I-V and C-V characteristics of reverse biased BPW34F photodiodes, pre- and post-irradiation [1]. The sensors were irradiated at the MC40 Cyclotron of the University of Birmingham, the cyclotron at the Karlsruhe Institute of Technology, and the IRRAD proton facility at CERN, with the respective measured proton hardness factors being: 2.1±0.5 for 24 MeV, 2.2±0.4 for 23 MeV, and 0.62±0.04 for 23 GeV. The hardness factors used in these facilities are in agreement with the measurements.
Following a brief recap of the earlier measurements, the improved set-up for precision electrical measurements at the University of Birmingham will be presented, along with an investigation of the behaviour following irradiation of Hamamatsu high-ohmic silicon pad diodes will be presented. The I–V and C–V characteristics of the diodes are investigated under different biasing schemes, and the active volume of the depleted bulk silicon that contributes in the change of the leakage current between pre- and post-irradiation can be determined with accuracy. Investigations for improved dosimetry in the Birmingham MC40 cyclotron will be also discussed. These studies may open a window for higher precision determination of the hardness factors.

[1] P. Allport et al., "Experimental Determination of Proton Hardness Factors at Several Irradiation Facilities," JINST 14 (2019) P12004 (arXiv:1908.03049).

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