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Proton-induced bulk damage in silicon pad-diodes

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It has been previously observed that silicon radiation damage depends on the type and energy of the radiation, even after scaling with the hardness factor derived from NIEL (Non-Ionising-Energy-Loss) hypotheses. Nowadays, little is known about the energy dependence of proton-induced bulk defects in silicon sensors.

In this work, 200 μm silicon pad-diodes were irradiated with protons (with kinetic energies of 23 MeV, 188 MeV and 23 GeV), up to a ϕ_{neq} (1 MeV neutron-equivalent fluence) of
$3{\cdot}10^{14}$ cm^{-2}. The investigated samples were fabricated on n- and p-type MCz (Magnetic Czochralski), FZ (Float Zone) and dd-FZ (Float Zone with deep diffusion) silicon crystals.
Current-Voltage (IV), Capacitance-Voltage-frequency (CVf) and Thermally Stimulated Current (TSC) measurements were performed at subsequent annealing steps at 80°C, for annealing times between 0 and 60 minutes.

A new TSC analysis method is presented, which implements the SRH (Shockley-Read-Hall) statistics for radiation-induced point-like and cluster defects. Several challenges posed by measurement and analysis of TSC spectra are discussed.
From the TSC spectra, the properties and introduction rates of the different defect states are derived. A strong correlation between the leakage current (from IV characteristics) and the concentration of defect clusters (from TSC spectra) is found. In addition, the impact of specific defects on the space charge will be presented by comparing the results from CVf and TSC measurements.

TRACK

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