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Radiation hardness of high resistivity n- and p-type magnetic Czochralski silicon

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An LHC upgrade with a luminosity increase of one order of magnitude has been recently envisaged. In this scenario, silicon detectors produced according to the present technologies would not withstand the increased radiation fluences.
Magnetic Czochralski silicon (MCz) can be a promising solution for future experiments due to its high intrinsic oxygen concentration, which improves the radiation tolerance. The INFN SMART Collaboration, a research project within the framework of the CERN RD50 Collaboration, recently started an R&D activity to study the properties and the radiation hardness of this material and a possible employment in high energy physics tracking systems.
A large set of MCz 4"wafers of 1 k□cm resistivity of both n- and p-type has been recently produced by Okmetic (Finland). Wafers were then processed at ITC-IRST in Trento (Italy), with a process tuned for low temperature steps. A few Float Zone (FZ) wafers were also processed with the same masks and process to allow a comparison with the present material.
The wafer layout contains a large number of multiguard diodes, specific test structures and microstrip sensors. Pre-irradiation properties were investigated to assess the manufacturing quality and the bulk properties. Diodes, together with other test structures, underwent an irradiation campaign with 24 GeV/c protons at CERN, 26 MeV/c protons in Karlshrue and nuclear reactor neutrons in Ljubliana, up to fluences of 8x1015 cm-2.
For all diodes, the effective dopant concentration and the leakage current were studied as a function of the annealing time at different temperatures and, according to the fluence and the bulk type, the type inversion could be observed. The increase in leakage current and the effective dopant concentration were also studied as a function of the fluence and both damage constant and beta parameter were measured. Bulk materials and irradiation types were also compared.
A thorough study on defects has been also performed on these diodes via Thermally Stimulated Currents. The occurrence of a shallow donor defect is observed in both types of material at 30 K after irradiation at of 4x1014 cm-2. Type inversion has been also investigated for fluences up to 1015 cm-2 by current transient spectroscopy: results are reviewed and discussed.

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