

Radiation damage in p-type EPI silicon pad diodes irradiated with different particle types and fluences

In view of the HL-LHC upgrade, radiation tolerant silicon sensors that contain low-resistivity p-type implants or substrates, like LGAD or HVCMOS devices, are being developed in the framework of ATLAS, CMS, RD50 and other sensor R&D projects. The devices are facing a particular problem - the apparent deactivation of the doping due to the irradiation, the so-called acceptor removal effect.

In the present work proton- and neutron-fluence dependent radiation damage effects, including change in leakage current and effective doping concentration, space charge sign inversion, but also introduction and annealing of point- and cluster-defects have been studied in Si pad diodes fabricated from p-type EPI material of different resistivity (10-1000 ohm-cm). Standard electrical characterizations (I-V, C-V), TCT (Transient Current Technique) and TSC (Thermally Stimulated Current) techniques were applied.

A correlation between effective doping concentration obtained from C-V measurements and defect concentration N_c extracted from TSC measurements for both neutron and proton irradiation is observed and pointing towards the microscopic origin of the acceptor-removal.

A detailed analysis of the dominant TSC peaks - E(30K), BiOi and three main deep acceptor levels H(116K), H(140K) and H(152K) - responsible for the changes in the effective space charge is performed. The origin and annealing behavior of E(30) and H(40) and other cluster-related defects are discussed as well.

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Session Classification: Poster Session B

Track Classification: Semiconductor Detectors