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Effect of proton irradiation in H+ implanted thermal donors induced semi-insulator passivated n+p-p+ Czochralski silicon detector: Impact on V20 formation

For the luminosity upgrade of the LHC CERN to 1035 cm −2 s−1 (Super-LHC or S-LHC), the presently available Si detector technology may not be able to match the extreme requirements with respect to the necessary radiation tolerance. The innermost tracker detectors will have to face particle fluences (jeq.) above 1016 cm −2, (equivalent to 1 MeV neutron dose) after 5 years of operation accumulating an integrated luminosity of 2500 fb −1 at the minimum instrumented distance from the collision point (ri = 4 cm). Due to the requirement of very high rate capability and spatial resolution together with the demand for a significantly improved radiation hardness, new detector designs and possibly new sensor materials have to be explored and developed. In one of my published work, semi-insulator passivated structures are getting higher breakdown voltage before high irradiation dose then certaintly its VBD will more increase after high irradiation dose than other types of high voltage planar devices. Now, Si detector passivated with semi-insulator is absolutely suitable to work in hostile radiation environment of S-LHC. Using n+/p−/p+ structures instead of conventional detectors can significantly increase the radiation hardness of Si particle detectors. It is known that leakage current increase after irradiations due to the formation of high concentration of deep level acceptor impurities, i.e. V2O. Before proton irradiation, if we implant high concentrations of H+ ions in samples especially in TDs induced semi-insulator passivated n+/p−/p+ Cz Si detector then number of H atoms will form inside the Si crystal lattice. In Table.1, for the first time we have shown the various reactions that take place in Si lattice on implantation with H+ ions and proton irradiation. In this regard, we have not considered the interstitial type reaction, PV (E- Centre) - type reaction, C-type, Fe-type reaction etc. It can be seen that TDs like formation of [SiO4] etc. also reduces the contribution of oxygen towards vacancy. It has been also found that H+ implantation in Si sensors will more reduce the formation of V2O after proton irradiation because most of the oxygen and vacancies concentration are reduced of which the formation of H2O, VOH, OH etc. and gets formation of V2O is suppressed and eventually the radiation hardness of Si detector is improved. Finally, a design is proposed to explain the higher radiation hardness of Si detectors for S-LHC.

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