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Comparative characterisation of nitrogen doped highly irradiated silicon sensors

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Envisaged circular hadron colliders challenge the existing silicon detector technologies in terms of unprecedented radiation doses and set stringent limits on the resolution and the material budget.
Since 2002 the RD50 Collaboration is dedicated to the development of radiation tolerant silicon detectors for high energy collider experiments. One promising approach for more radiation hard silicon sensors is the so-called defect engineering, where foreign atoms are introduced to the silicon bulk material, to alter the defect formations after irradiation. Previous investigations of nitrogen enriched material indicated a superior radiation tolerance.

The NitroStrip project is a common RD50 effort to investigate the effect of nitrogen doping on silicon strip sensors in comparative measurements. For this purpose sensors and diodes were produced from standard floatzone, deep oxygenated, Magnetic Czochralski and nitrogen enriched wafers.
Within this presentation, an overview on the various results obtained from the measurement campaign is given. The devices were electrically tested and irradiated to fluences between $1 \cdot 10^{13}\,\mathrm{n_{eq}/cm^2}$ and $1 \cdot 10^{15}\,\mathrm{n_{eq}/cm^2}$ with either protons at Karlsruhe, 23 MeV/c, and CERN PS, 24 GeV/c, or reactor neutrons in Ljubljana. The sensor behaviour after irradiation was then evaluated in terms of their charge collection using a beta source, measurements of the electric field distribution using an edge- and top-Transient Current Technique (TCT) setup, electrical measurements and measurements of the thermally stimulated currents(TSC) for defect characterisation. For a thorough understanding of the long term behaviour of the nitrogen enriched sensors, dedicated annealing studies were performed with annealing times corresponding to more than a year at room temperature. The various measurements of the irradiated sensors revealed no superior radiation hardness of the nitrogen enriched sensors. Hence additional SIMS measurements were performed, which concluded that the level of nitrogen in the processed sensors is below the detection limit. This indicates that the nitrogen content of the wafer is reduced during the sensor processing, which is currently under further investigation.

Submission declaration

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