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# Development of radiation hard silicon strip sensors using T-CAD simulations and comparison with subsequently produced detectors

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Position sensitive silicon detectors are largely employed in the tracking systems of High Energy Physics (HEP) experiments due to their outstanding performance. They are currently installed in the vertex and tracking part of the CMS experiment at LHC the world's largest particle physics accelerator at Centre for European Nuclear Research (CERN), Geneva.
An upgrade of LHC accelerator is already planned, namely the high luminosity phase of the LHC (HL-LHC foresee for 2023). The tracking system of CMS at HL-LHC will face intense radiation environment than the present system was designed for. This requires the upgrade of the full tracker that will be equipped with higher granularity as well as radiation hard sensors, which can withstand higher radiation levels and higher occupancies.
In order to address the problems caused by intense radiation environment extensive measurements and simulations studies requirements have been initiated for investigating different designs and materials options for Si micro-strip sensors.
The simulation studies of silicon detectors, based on commercial packages (Silvaco and Synopsys T-CAD), are performed in order to investigate sensor characteristics before and after irradiation for fluences up to $1.5 \times 10^{15} n_{eq}/cm^2$.
This work will demonstrate the development of radiation damage models for T-CAD studies and the subsequent simulations of new silicon sensor geometries.
On the basis of the Hamamatsu Photonics K.K (HPK) measurement campaign data of irradiated silicon strip sensors, an effective two-defect model was developed in order to reproduce measurements after proton and neutron irradiation from $1 \times 10^{14}\ n_{eq}/cm^2$ up to $1.5 \times 10^{15}\ n_{eq}/cm^2$ respectively.
After successful reproduction of data, new n-in-p sensor geometries have been simulated and studied on charge collection efficiency (CCE) and electrical breakdown behaviour. The most promising geometries have been designed and produced on a float-zone silicon wafer with Centro Nacional De Microelectronica (CNM) in Barcelona. The strip sensors have been irradiated to several fluences corresponding to the simulation input parameters and the HPK campaign and measurements have been done with the ALiBaVa fast read-out system based on the analogue Beetle chip. CCE results of the new sensors after irradiation are in good agreement with the CCE predicted by T-CAD studies with the Synopsys package as well as backplane capacitance and leakage current from measurements with probe needles.
Hence the effective defect model is sufficient for investigations of new sensor designs in order to withstand the harsh radiation environment for the HL-LHC era. Furthermore, with T-CAD it is possible to access the electric field distribution in the bulk and to visualize possible hot spots which can not be directly investigated with experimental setups.
This poster covers the development of the effective defect model for T-CAD simulation studies of new n-in-p technology sensors and the subsequent production of the sensors. The agreement of simulation and experimental data demonstrates that T-CAD studies represent a powerful tool for design studies of new radiation hard silicon detectors.

**Primary author:** PRINTZ, Martin (KIT - Karlsruhe Institute of Technology (DE))

**Co-authors:** MESSINEO, Alberto (Sezione di Pisa (IT)); BHARDWAJ, Ashutosh (University of Delhi (IN)); LALWANI, Kavita (University of Delhi (IN)); RANJAN, Kirti (University of Delhi (IN)); DALAL, Ranjeet (University of Delhi); EBER, Robert (KIT - Karlsruhe Institute of Technology (DE)); EICHHORN, Thomas Valentin (Deutsches Elektronen-Synchrotron (DE)); PELTOLA, Timo Hannu Tapani (Helsinki Institute of Physics (FI))

**Presenter:** PRINTZ, Martin (KIT - Karlsruhe Institute of Technology (DE))

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