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TCAD Simulations of Radiation Damage Effects at High Fluences in Silicon Detectors with Sentaurus TCAD

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In this work we propose the application of a radiation damage model based on the introduction of deep level traps/recombination center suitable for device level numerical simulation of radiation detectors at very high fluences (e.g. 1-2x10^16 1 MeV equivalent neutrons).

The model is based on a past modeling scheme featuring three levels with donor removal and slightly increased introduction rate to cope with direct inter-defect charge exchange. This was successfully adopted for the optimization of the substrate resistivity and geometrical configuration of the electrodes of the inner silicon strip tracker of the CMS experiment at LHC.

The new fluences expected at the SuperLHC impose new challenges and the extension of the model (valid up to 1x10^15 n/cm2) is not straightforward. New effects have to be taken into account (e.g. avalanche multiplications and capture cross section dependencies on temperature and fluences), at the same time keeping the solid physically based approach of the modeling (e.g. by using no fitting parameters). This will preserve the generality of the approach, allowing its application to the optimization of different kind of detectors.

We present the comparison between simulation results and experimental data taken from literature for p-type substrate structures in different operating conditions (temperature and biasing voltages) for fluences up 2.2x10E16 n/cm2 (Fig. 1).

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