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TCAD advanced radiation damage modelling in silicon detectors

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In this work we present the development of a comprehensive (surface and bulk) TCAD radiation damage effects model which enables a predictive insight into the electrical behavior of novel solid-state detectors up to the particle fluences expected at the end of HL-LHC.
To better understand in a comprehensive framework the complex and articulated phenomena related to the radiation damage mechanisms TCAD simulations have been carried out and compared with measurements performed on several test structures and sensors. In particular, surface radiation damage effects have been deeply investigated on both p-type and n-type substrate test structures exposed to X-ray irradiation at doses in the range 0.05-100 Mrad(SiO2). By analyzing the properties of the SiO2 layer and of the Si-SiO2 interface as a function of the dose physically meaningful parameters such as the integrated interface trap density and the oxide charge, peculiar to different vendors/technology options have been extrapolated from measurements aiming at the TCAD model validation. The complete bulk and surface radiation damage model findings have been then compared with available measurements in terms of charge collection efficiency up to 2×10 16 1 MeV equivalent n/cm2. The predictive capabilities of the combined surface and bulk new University of Perugia TCAD model can be therefore exploited for the design and optimization of the new generation of silicon detectors to be used in future HEP experiments.

Primary authors: MOROZZI, Arianna (INFN, Perugia (IT)); MOSCATELLI, Francesco (Universita e INFN, Perugia (IT)); PASSERI, Daniele (Universita e INFN Perugia (IT)); BILEI, Gian Mario (Universita e INFN, Perugia (IT))

Presenters: MOROZZI, Arianna (INFN, Perugia (IT)); PASSERI, Daniele (Universita e INFN Perugia (IT))

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