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Electrical-modeling and simulation of cumulative radiation effects in semiconductor pixels detectors: prospects and limits

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Silicon detectors have gained in popularity since silicon became one of widely used micro/nanolectronic semiconductor material. In particle physics as well as for room radiation detection or imaging , silicon is now a common feature for pixel based detecting systems. Over the past twenty years a lot of experimental efforts have been focused on the effects of ionizing and non-ionizing radiation on silicon pixels. Most of this research was done in the framework of high luminosity particle physics experiments, along with radiation hardness studies in basic semiconductors devices. In its simplest form the Si detectors reduce to a PIN or PN structure partially or totally depleted, or in some other cases MOS structures. Bulk or surface defects affect considerably the transport of free carriers and therefore some modeling of the effects of deep defects can be done in a conservative way, using existing or experimentally obtained data. The proposed method to design a pixel detector is based on the use the electrical properties of points or extended defects either at the interfaces or in the bulk. Their electrical and physical properties are introduced in a standard code in order to make predictive simulations. The proposed procedure can be used to study pixels detectors with different geometrical structures and alternative semiconducting materials. Its purpose is to provide an alternative to tedious and extensive radiation tests.This could allow the development of defect annealing methods, which are necessary for the long term realiability of detectors. In this paper we will describe a general method for pixel design and we will show how it can be used on silicon and germanium pixels.

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