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TCAD simulation of the electrical performance of the ATLAS18 strip sensor for the HL-LHC

To cope with the increased occupancy and radiation dose expected at the High-Luminosity LHC, the ATLAS experiment will replace its current Inner Detector with the Inner Tracker (ITk), consisting of silicon-based pixel and strip sub-detectors. The strip detector will consist of many nˆ+-in-p sensors fabricated by Hamamatsu Photonics, with 300 um signal-generation thickness and approximately 75 um strip pitch. To guide the operation of these sensors in the ITk, it is desirable to understand the basic mechanisms underlying their performance, including the effects of the radiation fluence (up to 10ˆ15 1-MeV neq/cmˆ2) expected during operation.

To this end, we have used Sentaurus TCAD to develop a 2D simulation of the ITk large-format strip sensor, based on detailed optical and electrical measurements of the sensors and of test devices fabricated on the same wafers. Sensor IV and CV behaviour is reproduced in the simulation by implementing charge trapping due to defects in the silicon, either inherent or radiation-induced. Trapping parameters are informed by existing frameworks, such as the Perugia model of surface and bulk radiation damage, and by deep-level transient spectroscopy of the wafers. In addition, the regions of the sensor involved in early breakdown - located through measurements of optical emission - are investigated, as well as the humidity dependence of early breakdown. These simulation results help validate the performance of the ITk strip sensor throughout its operational lifetime.

Submission declaration

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