13th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors (HSTD13), Vancouver, Canada

Contribution ID: **118** Type: **Poster**

Understanding the Humidity Sensitivity of Sensors with TCAD Simulations

During the prototyping phase of the ATLAS Inner Tracker Upgrade for the High Luminosity project, several n-in-p large area silicon strip sensors showed signs of early breakdown when biased at a relative humidity (RH) higher than 20 %. To understand the sensor's humidity susceptibility, Synopsys TCAD simulation software was used to implement the geometry of n-in-p diodes, test structures placed on the same wafer as the main sensor. The electrical behavior of the diodes has been simulated for different effective RH values. The humidity effect was modeled using a thin resistive layer of polysilicon placed on top of the passivation. The sheet resistance of the polysilicon layer was adjusted according to literature values of the sheet resistance of the passivation surface as a function of RH. To crosscheck the simulation results, current-voltage measurements of the diodes have been performed until breakdown conditions were reached in a RH controlled environment. Hot-electron emission in the localized breakdown region was imaged using a near-infrared camera. Once the location of the avalanche breakdown is known, Top-Transient Current Technique (Top-TCT) scans are performed in the same positions. The distribution of the electric field estimated from TCT measurements is compared to the TCAD simulation results. By performing both simulations and measurements, we gain a better understanding of the evolution of the electric field and the accumulation of free charge carriers which lead to early breakdown in humid environments.

Submission declaration

Original and unplublished

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Track Classification: Simulations