Contribution ID: **23** Type: **WG3 - Radiation Damage - Extreme Fluence**

Investigation of ionizing radiation damage in the SiO2 layer in of silicon sensors for the CMS Endcap Calorimeter upgrade

Wednesday, June 19, 2024 11:10 AM (20 minutes)

The High-Luminosity Large Hadron Collider (HL-LHC) will present an approximately 10-fold increase in integrated luminosity relative to the aggregate of all previous LHC operational phases. Consequently, the CMS detector needs to be upgraded to withstand the increased radiation levels. The current endcap calorimeters will be replaced by the High-Granularity Calorimeter (HGCAL) which, additionally, is designed to significantly increase transverse and longitudinal segmentation compared to current calorimeters. The HGCAL sensors are fabricated on 8-inch p-type silicon wafers, featuring active layers of 300 µm, 200 µm, and 120 µm thicknesses and main cell sizes of 0.5 and 1cm2. The sensors have hexagonal layout to optimize wafer surface utilization and facilitate efficient tiling.

The objective of this study is to investigate the radiation-induced damage to the SiO2 layer of the HGCAL silicon sensors up to the doses expected at the end of the HL-LHC program. Different aspects of the radiation damage are investigated using dedicated test structures made from surplus segments of the silicon wafers hosting the HGCAL sensor. These structures include Metal Oxide Semiconductor (MOS) sensors, Gate Controlled Diodes (GCD) and microstrip sensors. Different oxide variants and sensor thicknesses are considered. The test structures have been exposed to X-ray irradiation up to doses of 1MGy, which is of the same order of magnitude of the expected dose at the end of the HL-LHC program. The electrical characterization of the test structures was conducted in situ, in order to minimize the effect of thermal annealing. Both irradiation and measurements are performed at a controlled temperature of -20C. After the irradiation, the thermal annealing of the radiation damage was studied at room temperature. These results have been a crucial input to the choice of silicon oxide variant currently used in the production of the HGCAL sensors.

Type of presentation (in-person/online)

in-person presentation

Type of presentation (scientific results or project proposal)

Presentation on scientific results

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Session Classification: WG3/WP3 - Extreme fluence and radiation damage characterization