The Silicon Sensors for the High Granularity Calorimeter of CMS

Peter Paulitsch on behalf of the CMS collaboration

Background

The High Luminosity LHC (HL-LHC) will have a factor 5 higher instantaneous luminosity compared to the end of LHC operation, resulting in a proportionally higher event rate and a factor 10 increase of integrated luminosity (3000 fb⁻¹). Therefore, unprecedented levels of radiation and particle shower densities will affect experiments such as CMS. To address these challenges, the CMS collaboration will replace the existing endcap calorimeters with a new High Granularity Calorimeter (HGCAL) during the Phase-II Upgrade, around 2024-2026, which will include more than 600m² of silicon sensors to allow efficient mitigation of pileup and facilitate particle-flow calorimetry.

Sensor design

- 8" wafers, two cell densities (LD/HD)
- Thicknesses 120, 200, 300µm to cope with different levels of radiation
- 8" process is new in HEP, important differences from well-known 6": oxide charges, oxygen concentration of bulk, and fragile thin metal backside of 8"
- Hexagonal shape: A hexagon is the largest tileable, regular shape on a circular wafer
- Sensing elements are hexagonal, n-in-p, DC-coupled diodes
- Additional smaller, circular calibration diodes with lower capacitance to maintain MIP sensitivity after 3000 fb⁻¹
- Two guard rings (biased+floating)

Interpad structure

- Metal overhang to move peaks in E fields into oxide
- p+ implants (p-stops) to increase interpad resistance
- Two p-stop geometries under investigation: common and individual

Radiation hardness

- Total Ionizing Dose up to 2 MGy
- Fluence Φ dominated by neutrons (90%)
- Three sensor types for different Φ regions
  - 120µm (HD): 1x10¹⁵ n/cm²
  - 200µm (LD): 2.5x10¹⁵ n/cm²
  - 300µm (LD): 5x10¹⁵ n/cm²
- A full campaign was done on 6" sensors

References


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