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Radiation tolerance study using test-structure diodes from 8-inch silicon sensors for CMS HGCAL

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The High-Luminosity LHC will challenge the detectors with a 10-fold increase in integrated luminosity compared to the previous LHC runs combined, thus the CMS detector will be upgraded to face the higher levels of radiation and the larger amounts of data collected. The High-Granularity Calorimeter (HGCAL) will replace the current endcap calorimeters of the CMS detector. It will facilitate the use of particle-flow calorimetry with its unprecedented transverse and longitudinal readout/trigger segmentation, with more than 6M readout channels. The electromagnetic section as well as the high-radiation regions of the hadronic section of the HGCAL (fluences above $10^{14} n_{eq}/cm^2$) will be equipped with silicon pad sensors, covering a total area of 620m^2). Fluences up to 10^{16} and doses up to 1.5MGy are expected. The sensors are processed on novel 8-inch p-type wafers with an active thickness of 300μm, 200μm and 120μm and cut into hexagonal shapes for optimal use of the wafer area and tiling. Each sensor contains several hundred individually read out cells of two sizes (around 0.5 or 1.1 cm^2). With each main sensor several small sized test structures are hosted on the wafers, used for quality assurance and radiation hardness tests. In order to investigate the radiation-induced bulk damage, these sensors have been irradiated with neutrons at JSI (Jožef Stefan Institute, Ljubljana) to fluences between $6.5 \cdot 10^{14}$ and $1.4 \cdot 10^{16} n_{eq}/cm^2$. In this talk, the electrical characterisation and charge collection measurements of the irradiated silicon diodes will be presented. This includes the isothermal annealing behaviour of the bulk material, the frequency dependence present in capacitance measurements in irradiated sensors and the comparison of measurements conducted in two different experimental setups. The observed behaviour of the electrical properties and charge collection efficiency is in agreement with the HGCAL specifications. The results can be used to optimise the HGCAL layout and to establish an operating and annealing scenario for HGCAL.

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