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Testing HPK Planar Pixel Sensors for the CMS Phase 2 Upgrade

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With the High Luminosity upgrade of the Large Hadron Collider (HL-LHC), the Compact Muon Solenoid (CMS) experiment is foreseen to collect an integrated luminosity of 3000 or even 4000 fb^{-1}. This comes with up to 200 proton-proton collisions per bunch crossing and correspondingly a high multiplicity of particle tracks. For 3000 fb^{-1}, the upgraded CMS Inner Tracker will have to withstand 1 MeV neutron equivalent fluences ϕ_{eq} of up to 2.3×10^{16} cm^{-2} at a distance of 2.8 cm from the beam, whilst maintaining its track and vertex finding capabilities.

Planar n^+-p pixel sensor prototypes with pixel sizes of 50×50 μm^2 or 25×100 μm^2 and an active thickness of 150 μm were produced 2017 by Hamamatsu Photonics (HPK) and characterized in the DESY II test beam facility. A second set of revised prototypes was produced 2019, incorporating improvements of the sensor design based on findings from the 2017 production. The sensors were bump bonded to ROC4SENS or RD53A readout chips. The former is dedicated to sensor studies and the latter is a common ATLAS and CMS prototype for the HL-LHC. The sensor chip assemblies were irradiated with protons to fluences ϕ_{eq} of up to 2×10^{16} cm^{-2} before characterization in the test beam. The irradiations took place at PS-IRRAD Proton Facility at CERN, the Irradiation Center Karlsruhe and the Birmingham Irradiation Facility.

Even at the highest fluences hit efficiencies of 99 % are reached at bias voltages close to 650 V, thus a key requirement for sensors in the upgraded CMS Inner Tracker is fulfilled. At the given voltage the leakage current per pixel was about 5 nA at a temperature of about -32 °C. In addition, the presented results show the impact of the sensor choice on the hit efficiency, spatial resolution and crosstalk.

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