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Test Beam Characterization of Planar Pixel Sensors for the CMS Phase 2 Upgrade

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The CMS Inner Tracker for the High Luminosity upgrade of the Large Hadron Collider (HL-LHC) has to allow for tracking in a high track multiplicity environment caused by an instantaneous luminosity of up to 7.5×10^{34} cm^{-2} s^{-1}. In addition, the tracker has to tolerate 1 MeV neutron equivalent fluences ϕ_{eq} of up to 2×10^{16} cm^{-2} accumulating in the data taking period at 2.8 cm distance from the beam.

New n^{+}p-planar pixel sensors with pixel sizes of 50×50 μm^2 and 100×25 μm^2, 150 μm active thickness, with different implantation and metallization layout as well as different pixel isolation technologies have been produced by Hamamatsu Photonics (HPK). The sensors were bump bonded to a ROC4SENS or RD53A readout chip, where the former is dedicated to sensor studies and the latter is a common ATLAS and CMS prototype for the HL-LHC. Afterwards the sensor assemblies have been irradiated with protons at the PS-IRRAD Proton Facility at CERN and at the Irradiation Center Karlsruhe or neutrons in the TRIGA Mark II reactor in Ljubljana to fluences ϕ_{eq} above 5×10^{15} cm^{-2}. Finally, the sensors were characterized in an electron beam at the DESY II test beam facility.

The presented results show that these planar sensors reach efficiencies above 99 % at bias voltages well below 800 V even after proton or neutron irradiation to the given fluences. Thereby, planar sensors fulfill a key requirement for the second layer of the CMS Inner Tracker for the HL-LHC. Furthermore the comparison of different sensor designs provides input for the final sensor.

Future measurements on sensors proton irradiated to ϕ_{eq} of 1×10^{16} cm^{-2} and beyond will show if planar sensors are an option for the innermost layer of the CMS Inner Tracker in case of a replacement after half the operation period.

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