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AC-coupled pixel detectors for high luminosity environments

We report on manufacturing and testing of AC-coupled n-in-p pixel sensors for the usage in high luminosity environments. The detectors are produced at Micronova, Finland's national research infrastructure for micro- and nanotechnology, on magnetic Czochralski (MCz) p-type silicon wafers.
High leakage current caused by radiation damage in silicon is a significant source of noise in the readout electronics and limits their dynamic range. The AC- coupled design will substantially reduce the leakage current through the readout when compared to DC- coupled detectors, especially after heavy irradiation. With this design and by using MCz p-type silicon, we expect the detectors to show good radiation hardness.
To avoid complex p-stop/p-spray structures usually used for sensors with segmented n+ electrodes, we employ thin Al2O3 and HfO2 films as field insulation layer grown by Atomic Layer Deposition (ALD). Due to the presumably negative oxide charge of the thin film(s), we expect it to prevent accumulation of electrons between the pixels and thus to provide excellent surface passivation and inter-pixel insulation. Biasing is realized via thin film titanium nitride (TiN) resistors. Details can be found in references [1,2].
The pixel pattern of our sensor matches the layout of the PSI46dig readout ASIC, which is currently used in the inner tracking detector of the CMS experiment at the LHC [3]. In addition to standard characterization techniques performed on the sensors, such as IV, CV and TCT measurements, we also tested fully assembled detectors, which were flip-chip bonded to the PSI46digV2.1-r readout chips. The tests were performed using various X- and gamma-ray calibration sources and the results will be presented here in detail. The impact of bias line design, bias voltage, and threshold settings of the readout chip on detector performance will be discussed. To evaluate the radiation hardness of our sensors, we are performing irradiations with high proton fluences (> 1015 protons/cm2) using a 10 MeV proton beam, followed by a comparative study of non-irradiated and irradiated sensors.

References

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