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AC-coupled pixel detectors with aluminium oxide field insulator on p-type MCz silicon

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In previous work, we have reported on the fabrication of pixel detectors on p-type magnetic Czochralski silicon substrates, employing a layer of aluminium oxide (Al_2O_3) grown by atomic layer deposition (ALD) as dielectric and field insulator. The high dielectric constant of Al_2O_3 facilitates implementation of capacitive coupling, which separates the signal from the significantly increased leakage currents caused by radiation damage in the silicon detector. In addition, Al_2O_3 exhibits a negative oxide charge and thus serves as a substitute for p-stop/p-spray insulation implants between pixels. The charge and interface properties of the Al_2O_3 film can be to some extent tuned by the ALD process, most importantly by the choice of oxygen precursor.

Devices obtained by the abovementioned process are characterized by CV, IV, and TCT measurements. Results show the expected high negative charge of the Al_2O_3 dielectric, and acceptable leakage current densities. Capacitively (AC) coupled n+-in-p pixel detectors, in a geometry of 80×52 pixels in 26 double columns, are flip-chip bonded to the current CMS PSI46dig readout ASIC for further testing. The functionality of these assemblies, including determination of suitable threshold settings in the readout ASIC, is studied with x-ray/gamma radiation sources.

A future development to improve AC-coupled pixel detectors features the use of hafnium oxide (HfO_2), also deposited by ALD, as an additional high-k dielectric layer in the area of the pixel implant. HfO_2 has very low oxide charge and thus does not interfere with the field-effect passivation provided by Al_2O_3 . However, its chemical inertness makes HfO_2 difficult to pattern by wet and fluorine-based dry etching. We are therefore currently investigating chemical-mechanical polishing (CMP) for patterning our HfO_2 films.

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