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Comparison studies of heavily irradiated dielectrics for AC-coupled pixel detectors on MCz silicon

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The motivation of this study is the development of next generation capacitively coupled (AC-coupled) pixel sensors with coupling insulators having good dielectric strength and radiation hardness simultaneously. The AC-coupling insulator thin films were aluminum oxide (Al_2O_3) and hafnium oxide (HfO_2) grown by Atomic Layer Deposition (ALD) method. The Al_2O_3 thin films were patterned for finely segmented structures by traditional wet etching, whilst HfO_2 was patterned by Chemical Mechanical Polishing (CMP) into structures defined by Reactive Ion Etching (RIE).

We will be presenting results based on the comparison study of the dielectric material used in MOS, MOSFET and AC-pixel sensors processed on high resistivity p-type Magnetic Czochralski silicon (MCz-Si) substrates. These devices were irradiated with 10˜MeV protons up to a fluence of 5e15 p/cm^2. Capacitance-voltage measurements of MOS and MOSFET test structures indicate negative oxide charge accumulation induced by proton irradiation. These studies are coherent to numerical simulations. Furthermore, current-voltage (I-V) measurements indicate very good dielectric strength performance in both the materials, even after proton irradiation. Electrical characterization to study the impact of different dielectric-silicon interfaces on the functionality of the AC-pixel sensors was further investigated by edge-TCT (Transient Current Technique) method. The negative oxide charge during the irradiation is an essential prerequisite of radiation hardness resiliency of $n^+/p^-/p^+$ (n on p) particle detectors widely intended to be used in future high-luminosity experiments.

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