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First characterization results of ARCADIA FD-MAPS after x-ray irradiation

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The ARCADIA collaboration is developing fully-depleted (FD) Monolithic Active Pixel Sensors (MAPS) in a 110nm CMOS process in collaboration with LFoundry. The sensor design incorporates an n+ collection node within a highly doped n-type epi-layer on top of a n-type substrate and p+ backside. Thus, the pn-junction sits on the backside and through an applied backside bias, the full substrate gets depleted. The targeted applications of this technology range from future high energy experiments to space applications, and medical and industrial scanners. Together, these applications set the minimum requirements on the detector; data collection at hit rates of (10-100) MHz/cm2, full signal processing within (1-10)us, maximum power consumption (5-20) mW/cm2 and radiation tolerances of up to 50krad or 1x10ˆ11 1MeV neutron equivalence fluence. In order to proof the performance of the technology, a demonstrator chip of 512x512 pixels with 25um pitch was designed and fabricated in a first engineering run in 2021, together with additional test structures of pixel and strip arrays with different pitches and sensor geometries. The production run has successfully produced functioning passive and active pixel matrices. In this contribution we will give an overview of the status of the project and present the main results, before concentrating on the first measurements of passive pixel matrices irradiated using an x-ray tube with a Tungsten anode, up to a dose of 10Mrad (SiO2). The measurements are complemented by TCAD simulations using three different parametrisations of the new Perugia model. The positive oxide charges and traps at the Si-SiO2 interface, introduced by ionizing radiation, have been shown to affect the depletion region around the collection electrode, increasing the pixel capacitance. By varying the gap size between collection node and pwells, the geometry can be optimized to keep the capacitance also low after irradiation. The measured and simulated CV curves, normalised per pixel and corrected for parasitic contributions of metal connections and probe pad, of the ARCADIA pixels with 50⊠m pitch are shown in Figure 1. The capacitances range for different layouts from 10 to 28fF per pixel, after a dose of 1Mrad and an applied Vptop voltage of -0.8V. The simulation results, shown as bands, reproduce the measured data within the errors at Vptop=-0.8V. This agreement validates the choice of geometries based on previous simulation studies and confirms the accuracy and reliability of the TCAD simulation models as a design tool for the next application-specific MAPS in ARCADIA process.

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