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Depleted Fully Monolithic Active CMOS Pixel Sensors (DMAPS) in High Resistivity 150 nm Technology for LHC

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Depleted monolithic CMOS active pixel sensors (DMAPS) have been developed to demonstrate their suitability as pixel detectors in the outer layers of the ATLAS Inner Tracker of High-Luminosity LHC. Since the charge collection by drift is mandatory to achieve the required radiation tolerance and timing resolution, sufficient depletion are needed. Two demonstrators have been fabricated in 150 nm LFoundry CMOS technology on high resistive (>2 kΩ·cm) wafer. Thanks to guard rings and sensor layout optimization, the break down voltage of the demonstrators is above 200 V.
The two demonstrator chips have several similarities (chip size of 10 mm x 10mm, pixel size of 250 μm × 50 μm with the same sensor layout, the same in-pixel analog electronics), but were designed with different purposes in mind. The first one has been developed to demonstrate the performances of the sensitive volume and analog in-pixel circuitry. The wafer was thinned to 200 μm and irradiated with neutrons of to fluence of $10^{15} n_{eq}/cm^2$, resulting in small performance degradation. The detection efficiency of un-irradiated and irradiated chip has been measured using 2.5 GeV electron beam. Total ionizing dose irradiation test of analog readout has been performed up to 50 Mrad. The degradation of the gain of the analog amplifier was evaluated to be smaller than 10 %.

The second demonstrator chip is fully monolithic DMAPS design. In addition to the sensitive volume and analog readout copied from the first design, it has in-pixel digital signal processing circuitry and additional periphery electronics, which allow fast readout. The digital architecture is similar to that of FE-I3, which is a readout chip of ATLAS pixel detector. First results show that this demonstrator chip is fully functional and the monolithic readout does not introduce too much noise into the sensor. The timing performances of before and after irradiation damage are currently under characterization using the full monolithic readout.

Primary author: HIRONO, Toko (University of Bonn (DE))

Co-authors: ROZANOV, Alexandre (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR)); BESPIN, Christian (University of Bonn); HUEGGING, Fabian (University of Bonn); ORSINI, Fabienne (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR)); GUILLOUX, Fabrice (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR)); KRUEGER, Hans (University of Bonn); CAICEDO SIERRA, Ivan Dario (University of Bonn (DE)); BARBERO, Marlon B. (CPPM - CNRS/IN2P3 / Aix-Marseille Université (FR)); VANDENBROUCKE, Maxence (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR)); DAAS, Michael (Universität Bonn); BREUGNON, Patrick (Centre National de la Recherche Scientifique (FR)); Mr PANGAUD, Patrick (CPPM, Aix-Marseille Université, CNRS/IN2P3 (FR)); SCHWEMLING, Philippe (Université Paris-Saclay (FR)); RYMASZEWSKI, Piotr (University of Bonn (DE)); GODIOT, Stephanie (Centre National de la Recherche Scientifique (FR)); WANG, Tianyang (University of Bonn (DE)); HEMPEREK, Tomasz (University of Bonn (DE)); DEGERLI, Yavuz (CEA - Centre d'Etudes de Saclay (FR)); WERMES, Norbert (University of Bonn (DE))

Presenter: HIRONO, Toko (University of Bonn (DE))

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