Contribution ID: **67** Type: **ORAL**

R&D status of the Monopix chips: Depleted monolithic active pixel sensors with a column-drain read-out architecture for the ATLAS Inner Tracker upgrade

Thursday 13 December 2018 11:10 (25 minutes)

We summarize the characterization status for two different depleted monolithic CMOS active pixel sensor (DMAPS) prototypes with a fully synchronous column-drain read-out architecture: LF-Monopix and TJ-Monopix. These chips are part of a joint effort aiming towards a suitable implementation of a radiation-hard DMAPS with a fast readout architecture for the HL-LHC ATLAS Inner Tracker (ITk) upgrade.

LF-Monopix (March 2017) was designed using a $150nm$ CMOS process on a highly resistive substrate ($> 2k\Omega - cm$), while TJ-Monopix (March 2018) was fabricated using a modified $180nm$ CMOS process with a $1k\Omega - cm$ epi-layer. The sensors differ on their front-end design, biasing scheme, pixel pitch, dimensions of the collecting electrode relative to the pixel size and the placement of read-out electronics within such electrode. The size of the pixel matrices is in the order of the current ATLAS Inner Detector chip (FE-I3) and their digital logic is able to cope with the projected hit rates in the out-most layers of the ITk.

Both chips were operational after thinning down to $100\mu m$ and backside processing for total bulk depletion in the case of LF-Monopix. Our results include measurements of their leakage current, gain, noise, threshold dispersions, timing, response to radioactive sources and efficiency in test beam campaigns. Moreover, we discuss the promising outcomes from the measurements after irradiation with protons up to a dose of $50Mrad$ and neutrons up to $1x10^{15} n_{eq}/cm^2$.

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Session Classification: Pixel sensor monolithic

Track Classification: Pixel sensor technology