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Radiation Hard Monolithic Pixel Sensors based on Small Collection Electrode: MALTA and miniMALTA.

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The MALTA (Monolithic pixel sensor from ALICE To ATLAS) is a monolithic silicon pixel sensor that has been designed in the 180 nm CMOS imaging process of TowerJazz. It was designed to be compatible with conditions like in the outermost pixel layer of the ATLAS ITk High Luminosity upgrade, with a required radiation hardness up to a fluence of $1 \times 10^{15}\, n_{eq}/cm^2$ and a TID of $80\, Mrad$. The MALTA sensor is a $2 \times 2\, cm^2$ large prototype, including a matrix of 512×512 squared pixel with a pitch of $36.4\, \mu m$. The pixel features a small collection electrode pixel, achieving a low input capacitance of about 2˜fF, and the matrix is red out using a novel asynchronous architecture. The low input capacitance, the front-end design and the implemented readout architecture yield a very low power consumption, $75\, mW/cm^2$ and $2.5\, mW/cm^2$ for analog and digital power, respectively, at the target data rate ($\sim 80\, MHz/cm^2$).
The promising results of the first chips (early 2018), before and after irradiation, triggered the development of two technology modifications to enhance the sensor radiation hardness. These fixes have been implemented first on a small scale prototypes, the MiniMALTA which was delivered in fall 2018, and then in a re-iteration of the MALTA chip, available in mid 2019. Both sensors have been tested in the laboratory and in a particle testbeam, demonstrating to achieve full efficiency after irradiation. The results of the tests will be presented.
The MALTA chip has been used to develop a CMOS compatible in-silicon buried channel technology (BCT) for sensor cooling, and to produce preliminary studies about the design of a large area CMOS detector ($> 4 \times 4\, cm^2$). The electrical test performed on a functional prototype after BCT processing and the large area detector studies will be presented as well.

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