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MALTA: an asynchronous readout CMOS monolithic pixel detector for the ATLAS High-Luminosity upgrade.

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The ATLAS tracking detector will be upgraded with the Inner Tracker (ITk) for the High-Luminosity Large Hadron Collider (HL-LHC) at CERN. The tracking system will be fully made of radiation hard silicon sensors. A process modification in a standard 0.18 micron CMOS imaging technology combines small, low capacitance electrodes of around 2 fF for the sensor with a fully depleted active sensor volume. The measurements on the first prototypes in this technology demonstrate a radiation hardness promising to meet the requirements of the ATLAS ITk outer pixel layers (1.5×10^{15} $1MeVneq/cm2$), with a fast signal response, compatible with the HL-LHC 25ns bunch structure. The front-end was optimised for this low capacitance to achieve low noise (ENC<20 e-) and low power operation ($1\mu W/pixel$).
After the encouraging results, two monolithic CMOS sensor prototypes a $20 \times 20mm^2$ monolithic CMOS sensor prototype Malta has been designed for the ATLAS ITk outermost pixel layer.
Malta features a 512×512 matrix of $36.4 \times 36.4\mu m^2$ pixels with a small electrode size of $\sim 2\mu m$, without clock distribution over the matrix and a fully asynchronous readout, designed to meet the challenging hit-rate requirements of up to $2MHz/mm^2$ in the outer layers of the ITk detector.
The sensor presents forty of the LAPA drivers, a pseudo-LVDS differential buffer designed for the data transmission over the full length of the ITk detector, with a data rate up to 1.28 Gb/s. The parallel outputs allow extensively studying the behaviour of the asynchronous pixel matrix.
Extended measurement results show that efficiency after irradiation is degraded especially in the pixel corners due to a higher threshold and larger pixel pitch ($36.4 \times 36.4\mu m^2$ instead of $25 \times 25\mu m^2$and $30 \times 30\mu m^2$), with respect to the first prototypes. The results have been confirmed by a well established synchronous architecture and different pixel layout, MONOPIX, developed in parallel with MALTA. Detailed comparisons on test beam measurements have correlated efficiency with deep pwell implants layout.
This initiated investigation to improve the lateral field in the pixel corners and achieve the desired radiation hardness, driving the design of new test structures.
The design of Malta will be presented together with laboratory and test beam measurements results, before and after irradiation, together with possible improvements.

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