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FASTpix - small collection electrode CMOS sensors for precise time-stamping capabilities, high efficiency in thin sensors and high radiation tolerance

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In the framework of the ATTRACT FASTpix project monolithic small collection electrode CMOS technologies for fast signal collection, high radiation tolerance and precise timing in the sub-nanosecond range are investigated.
Deep sub-micron CMOS technologies give access to very small, sub-femtofarad collection electrodes and large signal-to-noise ratios, essential for very precise timing in monolithic sensors. However, the small collection electrode design results in highly non-uniform electric and weighting fields in the sensor, that introduce variations of the charge collection times in dependence of the particle incident position, a key limitation for precise timing and radiation tolerance.
Within the FASTpix project sensor design modifications have been developed to mitigate these variations. Special implant structures have been designed that shape the electric field to uniformize the drift path within a pixel cell. In particular, reduced charge collection times in the pixel edges have been achieved, that reduce the charge sharing, increase the efficiency before and after irradiation and improve the time stamping capabilities. Additionally, a hexagonal arrangement of the collection electrodes has been found to mitigate slow charge collection at the pixel edges. Moreover, the hexagonal pixel geometry is also favorable for timing and efficiency measurements due to the reduced number of neighboring pixels, minimizing the charge sharing and therefore increasing the single pixel signal-to-noise ratios.
The FASTpix chip contains several mini-matrices with digital and analogue pixels and different sensor designs and geometries. Pixel pitches down to about 8.7 micrometer between collection electrodes are implemented in a 180 nm technology by placing only a minimum amount of circuitry inside the pixel matrix. The optimized well structures are implemented on a high resistivity epitaxial layer.
At present, the FASTpix has been investigated in laboratory measurements, showing the improved performance of the optimized designs even at small pixel pitches below 10 micrometer. This talk presents the concepts and results of 3D TCAD based sensor design optimizations as well as measurement results comparing different sensor designs.

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