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A 2D imager for X-ray FELs with a 65 nm CMOS readout based on per-pixel signal compression and 10 bit A/D conversion

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The unprecedented features of X-ray free electron lasers, capable of producing photon pulses with outstanding brightness and ultra-short duration, promise to revolutionise a number of research fields, including structural biology and chemistry, material science and nuclear and molecular physics. Specific instrumentation needs to be designed and fabricated to comply with the demanding specifications of the most challenging experiments at FELs, such as coherent X-ray diffraction imaging of non-periodic structures, also depending on the beam characteristics: wide dynamic range, single photon resolution at small signals, fast operation rate, minimum dead area, small pitch, radiation tolerance. The PixFEL project, funded by Istituto Nazionale di Fisica Nucleare, is the first step of a long term program aiming at building a large area, focal plane detector based on an active edge sensors interconnected to a dual layer front-end chip with onboard memory. The PixFEL collaboration is developing the main microelectronic blocks for the instrument, while exploring the enabling technologies for the final assembly. Active edge and slim edge pixel detectors have been simulated, designed and optimised for operation with X-rays in the 1 to 10 keV range, also accounting for potential plasma effects due to the large amount of energy released in the detector substrate. A first batch has been submitted, including test structures and arrays of pixels with splittings on pixel pitch and active edge termination. To read the signal from the detector, a front-end channel, compatible with a pitch of 110 um, has been designed in a 65 nm CMOS technology. Compliance with the 80 dB dynamic range typical of diffraction imaging experiments is achieved by means of a low noise preamplification stage with dynamic signal compression capabilities. Time-variant shaping is provided by a switched capacitor filter performing correlated double sampling. A low power, small area SAR ADC converts the analog sample to a 10 bit word. Promising results have been obtained from the characterisation of the test structures, including single blocks, full channels and an 8x8 array. The presentation will introduce the project, present the main test results and discuss the next steps.

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