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Pixel Detectors with Front-End Suitable for Amplitude Spectroscopy, Frameless Readout, and Per-Pixel Configuration

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Design of Pixel Detectors with analog front-end (AFE) that is suitable for amplitude spectroscopy, true event-driven readout, selective, i.e., per pixel, configuration and built-in testability is presented. The target is a pixelated sensors readout application specific integrated circuit (ASIC) based on front-end and backend technologies recently pursued by BNL, which include, for the front-end part, a charge amplifier operationally configured with active feedback network of the resistive-nature, employing the self-cascoded field-effect transistor topology for leakage current compensation and realizing trans-linear pole-zero cancellation for precise, cascadable input charge signal multiplication, and for the back-end part: 1) event-driven readout system, yielding non-priority access to on-a-chip readout resources, thanks to application of Seitz's arbiters both in the 'read request'part and 'access acknowledgment'path of the readout access arbitration architecture, 2) expansion of the event-driven system to asymmetric half-duplex communication, allowing per pixel, selective programming of configuration bits, with minimal addition of precious circuit resource, and, 3) testability features seamlessly incorporated into the readout and configuration framework.
The back-end concept is formalized and constrained in hardware description language for automated implementation of virtually arbitrary pixel fabric of a sensors readout ASIC's using the industry standard CAD/EDA tools. The concept forms a holistic conceptual framework called Configuration-Testability-Readout (CTR).
The AFE circuit network realizes continuous–time processing of input charge signals. The charge amplifier is followed by a shaping filter implementable within an area–constrained footprint of a pixel in finely pixelated sensors, catering to a broad spectrum of X–ray photon energies, spanning 2 keV even two orders of magnitude up. The design aims at a spectroscopic–grade energy resolution, achieving it, in the case of coverage of the energy band spanning more than one decade, through splitting the signal processing into high–and low–sensitivity paths. The same front-end is suited for photon counting, whereas using it in combination with the event driven readout is believed to yield the maximum achievable throughputs.
An illustration, showcasing the back-end design components of ASICs utilized for reading out pixel sensors, accompanied by depictions of the manufactured ASICs and the outcomes of testing of the event-driven readout is given in Fig. 1. There were fabricated small scale prototypes: with square 100 um^2-pitch or hexagonal 150 um^2-pitch pixels (including charge sharing compensation) as well as test structures aiming at benchmarking lossless readout and ability to automatically synchronize with a synchronous data acquisition.

I plan to submit also conference proceedings

Yes

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