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SCARLET: A new High-Rate and High-Resolution X-ray Spectroscopy Detector for Synchrotron XRF and XAFS Applications

Despite the effort in developing suitable detectors for X-ray fluorescence measurements at synchrotron light sources, e.g. for XRF and XAFS experiments, in many applications the capability of fluorescence spectroscopy detectors is rather limited. The high-rate performances of current detectors may be further challenged due to the ongoing machine upgrades or for the use in future sources where a factor between 10 and 100 of beam-on-sample fluxes may be increased with respect to the present conditions. Despite different commercial options for SDDs-based systems presently available, these are actually limited to single- or few-channel systems (4-7 units maximum). This motivates a new, sharp transition of this technology toward compact, multi-channels, high-density systems (hundreds of channels) to build high-resolution, high-rate and also versatile systems for synchrotron radiation applications. We propose the detector SCARLET (Sdd-asiC ARray for Large Events Throughput) aimed to cope with this challenge in the following years. The detector is based on monolithic arrays of SDDs (e.g. 8x8 units of 1mm² area each) bump bonded to a readout ASIC containing the full CMOS readout chain, from the charge preamplifier to the ADC. Although the detector-ASIC bump bonding architecture is rather popular in X-ray imaging detectors domain, it has not been significantly explored for X-ray spectroscopy-grade detectors and surely not for SDDs. The challenge here is to obtain a hybrid, monolithic detector based on SDDs with a high channel density but still keeping the adequate spectroscopy performances required by the target synchrotron applications. The readout chip will be composed by a CUBE preamplifier, a state-of-the-art CMOS preamplifier for SDDs for the first time integrated on the same chip with the remaining electronics analog chain, an analog shaping amplifier and an ADC for the on-chip data digitalization, a feature which allows to transmit data out of the detector with high robustness with respect to external pick-ups. At the shortest possible processing time, e.g. 100ns, an energy resolution better than 150eV at 5.9keV can be obtained, with an output counting rate larger than 1Mcps/channel, that, multiplied by the number of channels could allow to achieve several tens of Mcps/detector. The monolithic detector unit will be designed to allow a compact assembly of several units which could increase the count rate capability of the overall detection system up to few hundreds Mcps. This development could lead to a new generation of X-ray spectroscopy detectors for the next generation of high-brightness synchrotron experiments as well as for X-ray industrial applications.

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