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Characterisation of the noise performance of the HEXITEC-MHz ASIC

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STFC has begun work on a new generation of detector technology, capable of operating at MHz frame rates. The HEXITEC-MHz ASIC, developed for the HEXITEC-MHz detector system, is the first of these technologies and allows spectroscopic X-ray imaging up to frame rates of 1 MHz. At this frame rate it is possible to record per-pixel X-ray spectra for X-ray fluxes of >10^6 photons mm^{-2}s^{-1}, a 100× improvement over the original HEXITEC ASIC [1].

The ASIC is optimised for the detection of electron signals from materials including CdTe, CdZnTe, GaAs, and p-type Si and comprises an array of 80 × 80 pixels on a pitch of 250 µm. This array is divided into 8-pixel regions (2 × 4 pixels) called Super-Pixels. Each individual pixel is capable of measuring single X-ray photons with energies up to 200 keV and is readout, following in-pixel 12-bit digitisation via a time-to-digital converter with timing shared on a per Super-Pixel level. Digitised data is output over 20 serial outputs which operate at 4.1 GHz using the Aurora protocol. These specifications will allow the ASIC to be utilised across a broad range of applications, including energy-dispersive X-ray diffraction (EDXRD) [2], X-ray computed tomography [3], solar physics [4], and in studies of the chemical dynamics of the charge-discharge cycle of batteries [5] and alloy impurities [6].

In this paper, preliminary results relating to the characterisation of the HEXITEC-MHz ASIC and hybrid detectors will be presented. Test pulse measurements of bare ASICs, in which a voltage pulse is used to inject charge into individual preamplifiers, were carried out and equivalent Full Width at Half Maximum (FWHM) of ˜750 eV in CdZnTe were measured at ˜100 keV. These results will be presented alongside studies into the variation in performance across each device and the spectroscopic performance of hybrid detectors.

[1]M.C. Veale et al., HEXITEC: *A high-energy X-ray spectroscopy imaging detector for synchrotron applications*, *Synchrotron Radiat. News* **31** (2018) 28.

[2]D. O'Flynn et al., *Pixelated diffraction signatures for explosive detection*, *Proc. SPIE* **8357** (2012) 83570X.

[3]C. Egan et al., *3D elemental mapping of materials and structures by laboratory scale spectroscopic X-ray tomography*, *J. Phys. Conf. Ser.* **849** (2017) 012013.

[4]D. Ryan et al., *Modelling and measuring charge sharing in hard X-ray imagers using HEXITEC CdTe detectors*, *Proc. SPIE* **10397** (2017) 1039702.

[5]T. Connolley et al., *An operando spatially resolved study of alkaline battery discharge using a novel hyperspectral detector and X-ray tomography*, *J. Appl. Cryst.* **53** (2020) 1434.

[6]S. Feng et al., *Nucleation bursts of primary intermetallic crystals in a liquid Al alloy studied using in situ synchrotron X-ray radiography*, *Acta Mater.* **221** (2021) 117389.

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