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Hard X-ray applications of the HEXITEC hyperspectral detector

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HEXITEC is a hard X-ray detector that measures the energy of every X-ray interaction and presents the accumulated data over many frames as a spectrum per pixel. This full spectral information has become known as “colour”or “hyperspectral”X-ray imaging.

HEXITEC is based upon an ASIC manufactured in a 0.35µm CMOS process. It has 80 x 80 pixels on 0.25mm pitch with each pixel containing a charge sensitive amplifier, shaping amplifiers and peak hold circuit. The held voltage on the pixel is directly proportional to the energy measured on that pixel. The ASIC employs a rolling row readout to readout each pixel in turn with a frame rate of up to 9kHz. The ASIC is typically operated with fewer than 1 in 3x3 pixels measuring an X-ray per frame so that charge sharing events can be identified and corrected. The ASIC is gold stud and silver epoxy bonded to detector material including CdTe, CdZnTe and p-type Si with a matching array of 80x80 pixels and mounted on a mechanical block to form a detector module. The module is wire bonded to a PCB on one edge so that it can be tiled with a dead space of two pixels on three sides. The module PCB connects to readout electronics that digitise the signal, corrects for dark levels and provides the clock to operate the ASIC. The readout electronics are available as a single detector, 2x2 or 2x6 camera system. HEXITEC achieves <1 keV FWHM at 60 keV when operated in the range of 3 to 200 keV and can be used in a lower gain modality that will go to 600keV with a slight reduction in energy resolution.

HEXITEC has many applications where the hyperspectral X-ray measurements can provide additional information. In transmission X-ray imaging the energy spectra can be used to identify elements from their absorption edges or to distinguish between different tissue types in mammographic imaging. Full field of view X-ray fluorescence imaging has been demonstrated with a pinhole camera configuration with the aim of observing the elemental distribution during metal alloy solidification. Simultaneous energy and angular dispersive measurements have been made which show the ability to identify materials using standard X-ray tubes with applications in security screening. HEXITEC has been used in Compton scattering imaging, a synchrotron technique to infer the charge density of a material and has been used for in-situ imaging of battery charging and discharging. The fine energy resolution of HEXITEC is finding use as a prototype SPECT imaging camera for new theragnostic imaging modalities. The combination of many energy resolving pixels operating independently has found uses in characterising new laser driven radiation sources and some of their potential applications.
The detector operation and a selection of applications, developed with many collaborators from around the world, will be presented.

Summary

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