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Spectroscopic Imaging of Hard X-rays for Material Science Applications

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The HEXITEC and HEXITEC_{MHz} detector systems have been developed for spectroscopic X-ray imaging for photon science applications. Both systems consist of 80 × 80 pixels on a 250 μm pitch and utilise high-Z sensor materials for detection of X-rays in the energy range 2 –200 keV. The original HEXITEC system was capable of operating at a maximum frame rate of 9 kHz allowing per-pixel spectroscopy with an energy resolution of 800 eV to be captured at photon fluxes of up to 10⁴ photons s⁻¹ mm⁻² [1]. The 1 MHz continuous frame rate of the HEXITEC_{MHz} means that the same spectroscopic imaging can be carried out at photon fluxes of the order 10⁷ photons s⁻¹ mm⁻².

In this paper an update will be given on the current status of the HEXITEC technology and examples of how this has been applied for materials science applications. These examples will include the imaging and characterisation of in-operando lithium-ion batteries conducted at the I12 –JEEP beamline at the Diamond Light Source. In this experiment a monochromatic beam of 115 keV X-rays was used to illuminate a 0.25 mm thick slice through the width of a battery coin cell. The Compton scattered X-rays at 90 degrees to the battery were projected through a 0.2 mm pinhole to form an image on a 2 mm thick Redlen HF-CdZnTe HEXITEC detector. Images of the Compton signal were formed by integrating the counts around 93 keV with an integration time of 15 to 60 minutes. The strength of the Compton signal recorded at the detector was proportional to the ion density in the coin cell which evolves over the charging and discharge cycle. The battery cell was moved vertically through the beam to image slices through the cathode region of the battery cell. Using this technique, it was possible to image changes in the energy density of the battery during the charging and discharging cycle [2].

[1] M. C. Veale, et al., HEXITEC: A High Energy X-ray Spectroscopic Imaging Detector for Synchrotron Applications, Synchrotron Radiation News, 31, (6), 28-32, 2018. DOI:10.1080/08940886.2018.1528431

[2] K. Suzuki, et al., In operando quantitation of Li concentration for a commercial Li-ion rechargeable battery using high-energy X-ray Compton scattering, J. Synchrotron Rad., 24, 1006-1011, 2017. DOI:10.1107/S1600577517010098

Primary authors: SCHNEIDER, Andreas (STFC-RAL); Dr LUI, Andrew (University of Oxford); Dr HUANG, Ann (Kings College London); CLINE, Ben; DAY, Chris; SOLE, David (Science and Technology Facilities Council); Dr LIOTTI, Enzo (University of Oxford); Prof. SAKURAI, Hiroshi (Gunma University); CHURCH, Ivan (STFC - Rutherford Appleton Lab. (GB)); HOLDEN, John (Science and Technology Facilities Council); LIPP, John; NOBES, Joseph (Science and Technology Facilities Council); Dr SUZUKI, Kosuke (Gunma University); JONES, Lawrence; FRENCH, Marcus Julian (Science and Technology Facilities Council STFC (GB)); PRYDDERCH, Mark Lyndon (Science and Technology Facilities Council STFC (GB)); ROBERTS, Matt (Science and Technology Facilities Council); Mr HART, Matthew (UKRI Science & Technology Facilities Council); VEALE, Matthew; WILSON, Matthew (STFC); Dr MAGDYSYUK, Oxana (Diamond Light Source); SELLER, Paul (RAL); WHEATER, Rhian Mair (UKRI Science & Technology Facilities Council); CROSS, Simon (Science and Technology Facilities Council); Dr COLLINS, Steve (Diamond Light Source); Dr CONNOLLEY, Thomas (Diamond Light Source); GARDINER, Thomas; NICHOLLS, Tim (STFC (RAL))

Presenter: VEALE, Matthew

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