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Using EMCCDs with centroiding to achieve better than 5 µm spatial resolution for soft X-ray RIXS

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Advancement in synchrotron and free electron laser facilities means that X-ray beams with higher intensity than ever before are being created. The high brilliance of the X-ray beam, as well as the ability to use a range of X-ray energies, means that they can be used in a wide range of applications. One such application is Resonant Inelastic X-ray Scattering (RIXS).

RIXS uses the intense and tunable X-ray beams in order to investigate the electronic structure of materials. The photons are focused onto a sample material and the scattered X-ray beam is diffracted off a high resolution grating to disperse the X-ray energies onto a position sensitive detector. Whilst several factors affect the total system energy resolution, the performance of RIXS experiments can be limited by the spatial resolution of the detector used. Electron-Multiplying CCDs (EMCCDs) at high gain in combination with centroiding of the photon charge cloud across several detector pixels can lead to sub-pixel spatial resolution of 2-3 µm.

X-ray radiation can cause damage to CCDs by displacement of an atom in the crystal lattice, as well as the creation of surface traps due to dangling bonds at the Si-SiO₂ interface. Understanding the effect of radiation damage on EMCCDs is important in order to predict lifetime as well as the change in performance over time. Two CCD-97s were taken to PTB at BESSY II and irradiated with large doses of soft X-rays in order to probe the front and back surfaces of the device. The dark current was shown to decay over time with two different exponential components to it.

The paper will discuss the use of EM-CCDs for readout of RIXS spectrometers, and limitations on spatial resolution and pileup-limited count rate, together with any limitations on instrument use which may arise from X-ray-induced radiation damage.

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