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Characterisation and comparison of detectors for electrons in the range 10-20 keV

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Interest in direct detectors for low-energy electrons has increased markedly in recent years. Detection of electrons in the energy range up to low tens of keV is important in techniques such as photoelectron emission microscopy (PEEM) and electron backscatter detection (EBSD) on scanning electron microscopes (SEMs). The PEEM technique is used both in the laboratory, with sample excitation by UV light or electron beam, and on synchrotron light sources worldwide, where X-rays provide the sample excitation. The ubiquity of SEMs means that there is a very large market for EBSD detectors for materials studies.
Currently, the most widely used detectors in these applications are based on indirect detection of incident electrons. Examples include scintillators optically coupled to CCDs, or the use of microchannel plates (MCPs) with a phosphor screen and CCD camera. These approaches result in image degradation due to blurring in the phosphor, inefficiencies and distortions in optical systems, and the limited active area of MCPs. In principle, these difficulties can be overcome using direct detection in a semiconductor device. In practice, the limited penetration depth of low-energy electrons into such a device means that any dead layer at the surface affects the performance critically and must be minimised.
As part of a feasibility study into the use of a direct detector for use on an XPEEM, we have built at Rutherford Appleton Laboratory a system to illuminate detectors with an electron beam of energy up to 20keV. We have used this system to measure the performance of a custom back-thinned monolithic active pixel sensor (MAPS), a detector based on the Medipix2 chip, and a commercial detector based on MCPs. We present a selection of the results from these measurements and compare and contrast different detector types.

Primary authors: Dr MATHESON, John (STFC Rutherford Appleton Laboratory); Dr MOLDOVAN, Grigore (Point Electronic GmbH)

Co-author: Prof. KIRKLAND, Angus (University of Oxford)

Presenter: Dr MATHESON, John (STFC Rutherford Appleton Laboratory)

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