(Invited) Direct electron detectors for diffraction studies in the scanning electron microscope

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The scanning electron microscopy technique of electron backscatter diffraction (EBSD) [1-4] exploits diffraction of backscattered electrons to provide information on the structural properties of materials rapidly and non-destructively, with a spatial resolution of tens of nanometres, from large areas of the surface of a sample. In EBSD, the sample is tilted at around 70° to the normal of the incident electron beam. The impinging electrons are scattered inelastically through high angles forming a diverging source of backscattered electrons which can be diffracted. The resultant electron backscatter pattern (EBSP) consists of a large number of overlapping bands, known as Kikuchi bands, which are closely related to a 2D projection of the crystal structure. EBSPs are generally detected by an electron-sensitive phosphor or scintillator screen and a charge-coupled device (CCD) or complementary metal-oxide-semiconductor (CMOS) camera.

EBSD is a well-established technique for texture analysis and for quantifying grain boundaries and crystal phases [1-4]. The introduction of cross-correlation-based analysis of EBSPs has also made possible measurements of relative strain; geometrically necessary dislocations; lattice tilt and twist [3, 5]; antiphase domains [6]; and crystal polarity [7].

Direct electron detectors are being developed as a replacement for the conventional phosphor screen and visible camera combination [8-10]. The advantages of direct electron detectors include the ability to reduce the electron beam energy; beam current; and acquisition time compared with conventional systems. They also have high dynamic range, do not use distorting optics and energy discrimination of the backscattered electrons is also possible. This leads to improved lateral and spatial resolution and allows the acquisition of small-scale details in the EBSP not obtainable with conventional EBSD systems. This may provide routes to, for example, the determination of lattice constant; improved crystal phase identification; and the mapping of strain with greater sensitivity. The reduced voltage and current capabilities allow the microstructural analysis of materials which generally damage under the beam, such as halide perovskites, which are very promising materials for next generation solar cells [11].

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