Advances in Speed and Resolution with Direct Electron EBSD

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Electron backscattered diffraction (EBSD) in the scanning electron microscope (SEM) has evolved to be an indispensable technique in materials research for phase identification, crystal orientation determination, and lattice strain mapping. Further advancement in the technique would profit from the collection of EBSD patterns using high performance detectors. The ability to capture the patterns in high resolution is desirable for accurate quantification of material properties. In parallel, advanced applications of EBSD, such as 3D serial sectioning and in situ testing, demand high speed pattern acquisition while preserving the pattern quality for indexing.

The emergence of modern direct electron detectors (DEDs) has led to breakthroughs in transmission electron microscopy, as well as in EBSD [1, 2]. Here, we report the use of a modern DED that is designed and optimized for an SEM environment operating with primary beam energies between 3 and 30 kV. The high sensitivity and high resolution of the detector provides much improved pattern quality, and allows the detection of higher order electron diffraction features. This sensitivity also promises low voltage and/or low current EBSD. Low voltages lead to smaller interaction volume in the material and therefore better spatial resolution. Low currents are amenable to orientation mapping in dose sensitive or non-conductive materials (e.g. geological samples, ceramics).

Furthermore, the pixelated detector and fast readout speed allow the use of sparse sampling to accelerate EBSD pattern acquisition. By reading out fewer kernel rows from the detector and skipping the intermediate rows (Figure 1), the detector frame rate is significantly increased, yet without compromising the solid angle covered by the detector. We performed EBSD scan at increasing detector frame rates using sparse sampling, and evaluated different post-collection data processing methods, especially of inpainting the skipped pixels. Coupled with spherical indexing using EMSphInx [3], we demonstrate that reliable EBSD orientation mapping can be achieved at the speed of >5000 points per second.

References
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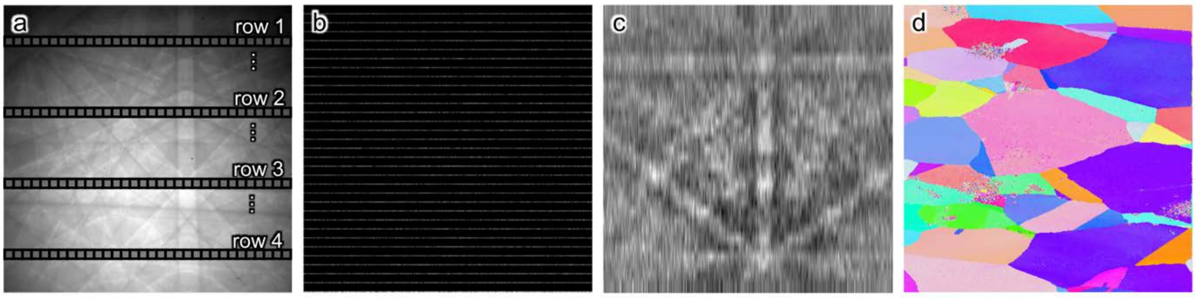

Figure 1. **(a)** Schematic of sparse sampling of an EBSD pattern. **(b)** Raw pattern acquired at 2200 frames per second, with 32 equally spaced kernel rows over the 2048×2048 pixels detector. **(c)** Post-processed pattern after background subtraction and inpainting. **(d)** Orientation mapping of a polycrystal Ni sample demonstrating the excellent indexing at the acquisition speed of 5150 points per second.