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Collection of Selected Area Electron Channeling Patterns (SACP) on an FEI Helios NanoLab Scanning Electron Microscope

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Electron backscattered diffraction (EBSD) has replaced electron channeling and selected area electron channeling patterns (SACPs) for many scanning electron microscopy (SEM) based crystallographic studies, due to the rapid collection rates and high spatial resolution of EBSD. Nevertheless, a number of SEM techniques, for example electron channeling contrast imaging (ECCI), are better served using SACPs rather than EBSD. This is because SACPs offer more accurate orientation determination relative to the SEM optic axis, whereas EBSD typically results in orientations determined relative to the surface normal of sample tilted 70º [1]. For ECCI, determining orientations with respect to the optic axis is critical in order to accurately establish specific channeling conditions and accurate deviation parameters [2].

Unfortunately, many commercially available SEMs do not offer the ability to collect SACPs. This is due in part to the ease of using EBSD in many applications, but also due to different microscope lens and scan coil configurations. TESCAN does offer SACP as an option on some of their microscopes, allowing SCAPs to be collected from areas approximately 10 µm in diameter. SACPs from areas as small as 0.5 µm have been collected on the Zeiss Gemini column [1] by rocking the beam using the lower aperture coils, but the software necessary to do this is not commercially available. The objective of the present work is to demonstrate the ability to generate SACPs from areas with ~10 µm diameters using an FEI Helios NanoLab 650.

The FEI Helios NanoLab, without modification, has all of the requisite hardware needed to generate a focused-probe rocking beam for SACP. For the purposes of this study, the system parameters were set as follows: 0.8µA probe current, 30kV acceleration voltage and 1mm electron beam aperture. The electron beam was focused onto the sample using C1 (an electrostatic condenser lens internal to the FEG module) with condenser C2 turned off. The beam was rastered using the upper quadrupole, which traditionally provides gun tilt/shift functionality. The UHR coil (an electromagnetic objective immersion lens) was set to maximum and the standard objective coil was set to maximum power. The scanning octupole plates were turned off. The backscattered electron signal was collected using the standard retractable solid state Si diode detector.

Figure 1 shows a series of images taken with the sample adjusted to different working distances. It is clear that the minimal distortion and noise of the image occurs at working distances around 4 mm. In contrast, at the extremes, 3.1 and 5.0 µm, both the channeling bands and the overall patterns become more distorted, with evidence of portions of the SACPs coming from multiple grains. The spatial resolution of the technique is demonstrated in Figure 2, which shows two pairs of images and corresponding SACPS for working distances of 4.0 and 4.6 mm. These pairs outline features that show up in the background of the SACPs that are correspondingly colored on the images. It is clear that the SCAP is collected from an area roughly 10 µm at 4.0 mm.

References:

[1] J. Guyon *et al*, Ultramicroscopy **149** (2015), p. 34.
[2] M.A. Crimp, Microscopy Research and Technique **69** (2006), p. 374.

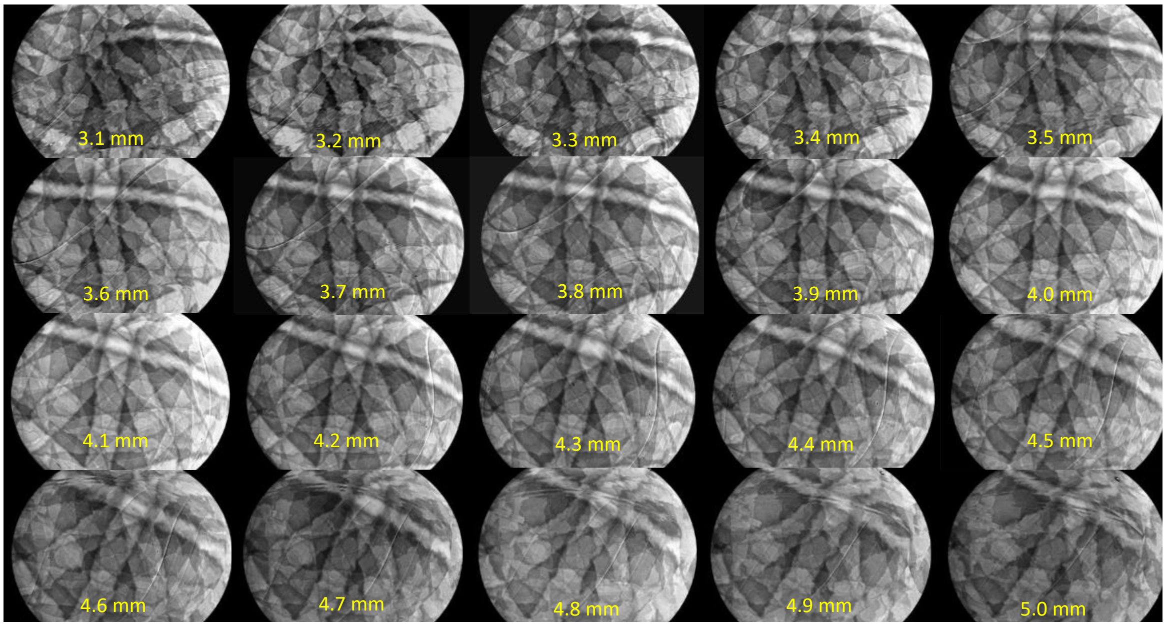

Figure 1. Series of SACPs collected at varying working distances showing the optimum working distance (beam rocking height) is ~4.0 mm.

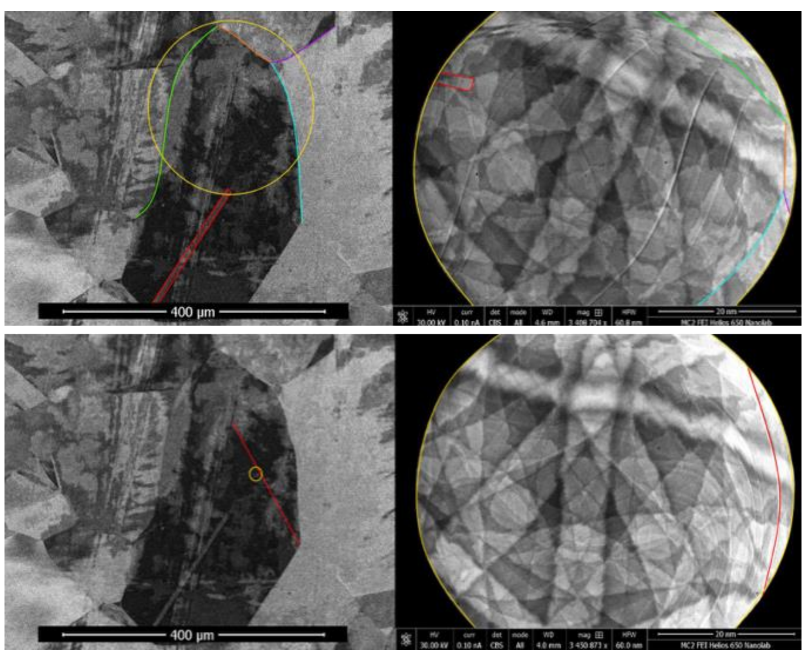

Figure 2. Top image and SACP collected at 4.6 mm working distance showing how features on image show up in background of SACP. Bottom similar image/SACP pair collected at 4.6 mm, showing most of the SACP collected from an area ~10 µm diameter area.

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