3D Imaging and Analysis

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Angular BSE Filtering for Topographic Information

D. Phifer[1], J. Pecher[2], P. Valasek[2], M. Petrek[2], T. Vystavel[2]

[1]FEI Company, Eindhoven, Netherlands
[2]FEI Company, Brno, Czech Republic

daniel.phifer@fei.com

SEM angular segmented solid state detectors can be used to filter topographic and compositional contrast with concentric ring detector segmentation designs [1]. Further subdivision of the topographic collection area into arches can yield additional information on the direction of sample surfaces and allow clear interpretation of topography. Since signal intensity is influenced by both sample topography and composition, the ability to separate one from the other is a useful parameter for potentially estimating scale of topography. Solid state detector diodes have been introduced with the ability to address concentric segment rings around the beam exit to separate high angle and low angle electrons (as shown in Figure 1). This works quite well to distinguish between composition and density on the inner rings closest to the beam and topographic information which is more prominent on the outer rings [1]. The relative direction of the surface collected is seen as uniform shading from one side of the image to the other. Segmentation into arch-shaped collection areas of the outer topographic rings allows collection of highly shadowed images which can be used for image analysis and potentially to quantify topography. Conventional segmentation of the detector such that there are 4 “quadrant” segments does not allow separation of atomic number effects on the topographic information as the inner (composition) and outer (topographic) information are both within a given signal collection area. Since BSE distribution is dependent on both composition and topography, the effect of a high atomic number region with topography may be exaggerated in respect to an adjacent low atomic number region due to the combined signal brightness and contrast. Direct signal is used for calculating height of topography based on contrast and brightness differences in the standard algorithms. The inability to separate brightness due to composition from that of topography could skew results if brightness and contrast are used as the determining factor for feature height, even when this is compared to a reference “off-axis” or 5th segment signal. This could be a contributing factor for why most surface model data is not so accurate with off-axis in the 3 or 5 segment BSE configurations [2]. Subdividing the outer “topographic” rings of concentric ring detector into three 60 degree “arch” segments allows separation of composition information (on the center ring) and allows characterization of directional information from “more pure” topographic content. An example of this is shown in Figure 2, where images from the inner ring and the three segments are shown. Shadowing is based on the direction of the sample surface and detector segment view of a sample orientation. Signal angular collection utilizing the unique BSE crystal segmentation provides new sample surface information. It is yet to be seen if angular filtering truly has the potential to create more accurate surface height representations in SEM imaging where composition can be removed from the equation or conversely used to refine the signal interpretation to yield better estimations because of the compositional signal differences. Software algorithms need to be developed to process this information whereby the ability to separate signal in this way can provide new insight into topographic surface characterization. This development presents a new opportunity to use direction-rich data for surface mapping and height measurements.

1. T. Vystavel, XIVth International Conference on Electron Microscopy (2011).
2. A. Agrawal et al, European Conference on Computer Vision (ECCV) (2006) p21.

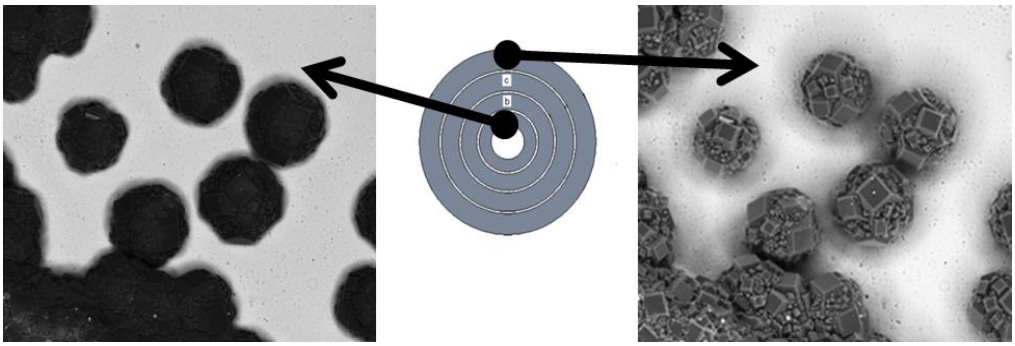

Figure 1. Angular filtering with concentric ring BSE segmentation clearly separates the atomic information form the innermost segment (right image) and topographic from the outer most segment (left image) content. Field width is ~23 microns.

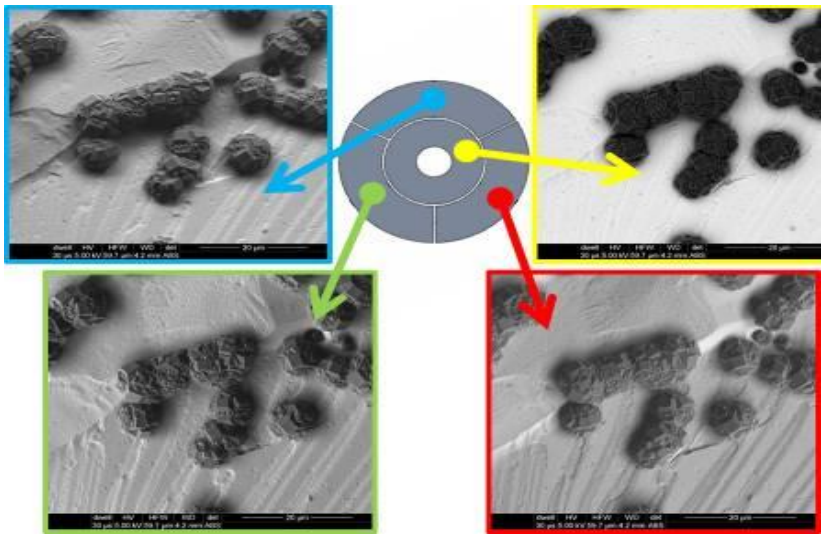

Figure 2. With an angular segmentation of the outer detector segments, separation of the topographic component is possible with angular direction yielding perspective shadows. This new information can be used to interpret the direction of slope in an image area in relation to neighboring pixels.