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Forward Modeling Applied to Serial Section Scanning Electron Microscopy and High Angle Annular Dark Field Tomography
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Modern characterization techniques, such as focused ion beam serial sectioning (FIBSS) and electron tomography, provide a relatively direct route to a full 3D quantification of a microstructure. Multi-modal data acquisition (for instance, simultaneous or asynchronous acquisition of secondary and backscattered electron images, electron backscatter diffraction maps, and energy dispersive x-ray signals) can generate a large amount of information from which a rather complete microstructure model can be obtained. However, merging/fusing of these data streams and segmentation of the microstructure continue to pose significant barriers to the routine application of these 3D techniques. In this contribution we will review a couple of promising approaches that employ forward modeling, i.e., the use of the proper interaction physics, to extract the microstructure from the data. Forward modeling (also known as model-based reconstruction) starts from a model of the microstructure (as obtained, for instance, from a preliminary reconstruction in the serial sectioning case, or a simple filtered backprojection in the tomography case) and computes what the images would look like if this primary result were the correct microstructure. Consideration of the differences between the predicted images/diffraction patterns and the experimental ones then allows one to construct an iterative algorithm to extract the best possible microstructure model, given an experimental data set and prior knowledge about the sample and the imaging modalities. We will illustrate this approach by means of two examples: FIBSS reconstructions using a simple physics-based model for the electron beam interaction volume, and high angle annular dark field electron tomography, employing a Rutherford scattering forward model that includes the direct beam and elastic diffraction contributions. Results from each approach as well as the underlying physics-based forward models will be discussed in detail.