# Discrete Tomography in Materials Science

S. Bals[1], K. J. Batenburg[2] and G. Van Tendeloo[1]

[1]*EMAT, Department of Physics, University of Antwerp, Belgium*
[2] *Centrum Wiskunde & Informatica, Amsterdam, The Netherlands*

## ABSTRACT

Over the last decade, electron tomography has become a powerful tool in the investigation of nanostructures in materials science. The possibility to obtain *qualitative* 3-dimensional (3D) information has already taken nanocharacterization to a new level, but gaining access to *quantitative* 3D information is the next step in the evolution of electron tomography. The increasing demand for quantitative results in 3D is not only driven by new developments in nanotechnology, but also by theoretical modeling studies that exactly require this type of information.

The so-called “missing wedge” has mostly been considered to be the main factor preventing reliable quantification of a 3D reconstruction. The missing wedge is related to the fact that it is often impossible to tilt a sample over 180°, due to the limited area for the sample holder in between the objective pole pieces of the microscope. The lack of 2-dimensional (2D) projection images for a certain range of angles will consequently result in a “missing wedge” of information in Fourier space, which will cause artifacts in the final 3D reconstruction. Although these artifacts may already hamper a qualitative interpretation of the 3D data, they will completely prevent quantification of 3D results. Therefore, several novel tomography holders and acquisition schemes have been developed [1-3]. However, despite these efforts, quantitative interpretation of a 3D reconstruction is still not straightforward. Here, we therefore evaluate the use of so-called "discrete tomography" for quantitative electron tomography in materials science.

Discrete tomography is an alternative reconstruction technique that uses prior knowledge on the object that has to be reconstructed [4,5]. More specifically, an estimate of the number of different gray levels (corresponding to different compositions) that can be expected in the original object serves as an input. One of the advantages of this approach is an improvement of the quality of the reconstructions in comparison to reconstructions based on the conventional reconstruction algorithms. Moreover, if the number of possible gray values is small, it is often possible to obtain very accurate reconstructions based on a few projections. Furthermore, missing wedge artifacts are strongly reduced, and segmentation is performed automatically during the reconstruction procedure, which will enable quantitative electron tomography. It will be shown that discrete tomography is therefore a very powerful tool to solve a broad range of materials science problems ranging from the 3D study of carbon nanotubes to semiconductor devices.

## REFERENCES

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