

Alternative routes for 3D imaging in a TEM

Electron tomography is a powerful tool for determining the three-dimensional (3D) structure of nanomaterials, even at atomic resolution. These results can be used for a better understanding of material properties and functionality at the most fundamental level. Usually, electron tomography measurements are carried out at standard TEM conditions that are often irrelevant to the use of nanomaterials in real applications. However, modern TEM instrumentation enables one to carry out heating experiments, apply electric bias to the sample, or study specimens in gas and liquid environments inside the microscope, albeit for 2D imaging. In combination with electron tomography, in situ TEM would allow to perform a dynamic characterization of changes in the 3D structure of nanoparticles under realistic conditions. Such knowledge would enable one to predict the evolution of their properties. Unfortunately in situ electron tomography is challenging because of the narrow tilt range of dedicated in situ specimen holders. Moreover, the acquisition of a conventional tilt series for electron tomography takes at least 1 hour, which is too long to capture the fast changes of the materials when exposed to relevant conditions.

In this talk, I will discuss alternative routes of retrieving 3D information, which do not require the acquisition of tilt series over a large tilt range. These approaches are inspired by techniques used in scanning electron microscopy for specimen surface reconstruction and are based on the registration of secondary electrons (SEs) or backscattered electrons (BSEs), which also can be detected in TEM mode. The most metrologically accurate approach is so-called “stereophotogrammetry”, which consists of acquiring two images of the same object along directions with a small angle between them. Height information can then be calculated trigonometrically. Another method to reveal the third dimension employs a segmented BSE detector and only requires taking one “shot” of the sample since all four images are acquired simultaneously by the different segments [1]. The final part of my talk will be devoted to signals detection inside the TEM and our first results in the design of SE and BSE detectors. Particularly, I will be talking about the calculation of the optimal parameters for solid-state BSE detector and the ability for SE imaging using electron beam induced current produced by SE emission [2].

References

- [1] C. Mignot, *Micros. Today*, 26 – 3 (2018).
- [2] M. Mecklenburg, *Ultramicroscopy*, 207 – 112852 (2019).