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IM3-O-2824 The choice of the right beam energy for analytical (scanning) transmission electron microscopy

Stöger-Pollach M.[1]

[1]USTEM, TU Wien, Vienna, Austria

Email of the presenting author: stoeger@ustem.tuwien.ac.at

Analytical electron microscopy aims for the detailed analysis of pristine specimens. Although this sentence sounds so trivial and self-evident, it contains a task that is indeed difficult to master. It is the preservation of the original state of the sample without generating radiation damage through electron bombardment. The best-known forms of radiation damage are knock-on damage and radiolysis. While radiolysis is mainly a problem for organic samples and increases with lower radiation energy, knock-on damage is a significant problem for inorganic samples at elevated electron energies. Knock-on damage does not necessarily mean that atoms have to be knocked out of the sample. It also describes the creation of point defects. The latter often cannot even be detected by means of high-resolution microscopy. Nevertheless, they can massively influence the analytical signal in terms of quenching and the generation of additional signals [1].
Another aspect for the correct choice of acceleration voltage is the generation of unwanted signals, which can overlap with the signals of interest. These include the Vavilov-Cerenkov radiation in the cathodoluminescence (CL) signal [2] and the corresponding energy losses in electron energy loss spectrometry (EELS) [3] but also the corresponding surface excitations, also known as light guide modes. The latter are excited on the top and bottom surface of the sample and can generate significant interference patterns in thin samples.
As a consequence, modern electron microscopes require a Consequently, modern electron microscopes require great flexibility in terms of the accelerating voltages available not only for imaging but also for spectroscopy. While CL analyses can be performed independently of the beam energy, since the optical components do not have to be adapted to the electron energy, this is different in EELS. Here, too, great energy flexibility is required.
In the present work, we show the influence of the beam energy on the CL and EELS signal for different semiconductor materials. For this purpose, we use our EEL spectrometer with high angular resolution and various high voltages. In comparison, CL spectra are recorded to quantify the Vavilov-Cerenkov radiation. Additionally, we study beam damage by observing quenching in CL, which is the most sensitive measure in this context.

[1] M. Stöger-Pollach et al., Ultramicroscopy 200 (2019) 111-124
[2] M. Stöger-Pollach et al., Ultramicroscopy 214 (2020) 113011
[3] M. Horak and M. Stöger-Pollach, Ultramicroscopy 157 (2015) 73-78