Advances in EELS Electron Spectroscopic Imaging for Low Energy-losses

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Particularly valence electron energy-loss spectroscopy carried out in STEM or in EFTEM mode has recently proven to be powerful for characterising nanostructured devices and functional materials, for instance with respect to semiconductor band-gap analysis or plasmonics, as these measurements can be carried out locally with nanometer resolution on the features of interest.

Scanning near field optical microscopy (SNOM) and dark field illumination (DF) have demonstrated to measure the absorption or scattering spectrum of single nanoparticles. However, these methods are limited in their ability to spatially resolve the mode structure of the plasmons. Recently, it could be shown that the optical plasmon modes of single nanoparticles can be successfully imaged with EELS in a STEM [1, 2]. Alternatively, we have refined and implemented an intensity-adjustable EFTEM approach, based on spectrum imaging [3, 4, 5].

The bandgap regime (~ 1–10 eV) is difficult or impossible to explore with optical methods, where momentum transfer studies are also not available. With a gun monochromator in combination with a high-resolution EELS spectrometer or imaging energy filter, offering about 100meV resolution, the tails of the zero loss peak are significantly reduced and the peak itself regains symmetry, aiding the processing of the low intensities in that energy region for this kind of analysis [6].

Measurements involving the low-loss region in general are complicated to carry out as the high dynamic range of an EELS spectrum prevents the simultaneous acquisition of different spectral parts with comparable statistics. Instrumental modifications to the energy filter such as an electrostatic shutter plus an electrostatic vertical deflector and a new CCD camera implemented for the first time world-wide at the FELMI in collaboration with Gatan, now allow the recording of the elastic and inelastic regime at nearly coincident times [7]. This approach offers the possibility to perform truly quantitative measurements, as the ZLP (and low-loss), acting as an energy reference and deconvolution kernel, now readily yields absolute edge energies in addition to elemental concentrations from single scattering spectra.

The intention of this paper is to show results achieved in these interesting fields of research along with recent data obtained from the modified energy-filter.

References

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