Enhancement of resolution in core-loss and low-loss spectroscopy in a monochromated microscope.

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Enhanced energy resolution has been achieved in the new generation of monochromated microscopes [1] through significant improvements in all components of the microscope as demonstrated in the work of Tiemeijer et al. [2] and Brink et al. [3]. A different approach to improve the resolution is to use numerical methods to enhance the features present into the EELS spectra. Various algorithms have been recently been developed by Gloter et al. and Ishizuka et al. [4,5]. These numerical methods seem to successfully improve the resolution in various core-loss spectroscopy applications. Whereas core-loss spectroscopy provides key useful information on the chemical state of elements, there is significant interest for the semiconductor industry and in fundamental research on electronic and optical properties of materials to explore the bandgap and the low-loss region of the spectrum. Our work demonstrates that even with a monochromated TEM, significant challenges appear to exist to detect and reliably measure the energy of localized states within the gap or the bandgap energy when this value approaches 1eV. In this respect a very interesting question is to which extend the deconvolution will improve the measurements accuracy of the bandgap energy.

The best evaluation of the deconvolution software is done by comparison of deconvoluted EEL spectrum taken without monochromator with data acquired with monochromator from the same area. Core loss spectra from several samples (e.g. Si L₂,3) have been acquired with and without the monochromator activated. The non-monochromated spectra were subsequently processed with various deconvolution algorithms and then compared with data obtained with the fully activated monochromator. The results show that the deconvolution is not always successful in improving resolution and the results may not be reliable.

As test examples for the low loss region, we have used Si and GaN low loss spectra acquired with and without the monochromator. Using the Richardson-Lucy algorithm [4] we have been able to remove the contribution of the tail of the ZLP and allow an easier access to information starting at about 0.5eV (when the monochromator is activated) or 1eV (when the monochromator is not activated). Results on more materials including metals and low-bandgap semiconductors will be presented.

References