Modelling STEM imaging based on core-loss spectroscopy

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Several factors contribute to the formation of images in scanning transmission electron microscopy (STEM), sometimes leading to results that are counter-intuitive. These factors include the propagation of the probe through the sample, the “delocalization” of the inelastic scattering on which the imaging is based [1], and whether the interaction can be realistically described by a “local” or “object function” approximation. The development of aberration correctors for the probe forming optics [2] has led to sub-Ångstrom probes which are more readily thermally scattered from the atomic columns in crystalline samples. This results in an enhanced signal from electrons that are “dechannelled” by thermal diffuse scattering (TDS) and this needs to be correctly modelled. The importance of TDS is illustrated in FIG. 1(a), where STEM electron energy loss spectroscopy (EELS) images based on the Ag M-shell signal are simulated. The peaks in the EELS signal occur not on the atomic columns but between them. The non-local nature of the effective inelastic scattering potential for EELS is also important in the formation of STEM EELS images. A simulated EELS signal derived from C K-shell ionization is shown in FIG. 1(b). The line scan through the Si/C dumbbells shows unexpected behaviour - the signal from the C K-shell is actually larger when the probe is above the Si column, despite the C column effectively not being illuminated by the probe as one would expect if this effect were due to “cross talk”, than when the probe is above the C column.

FIG. 1. (a) Ag M-shell EELS image for the [001] zone axis and line scan along [100] (100 keV electrons, aberration balanced probe with 20 mrad aperture, detector semi-angle 20 mrad, energy window 40 eV). (b) C K-shell EELS image in SiC for [011] zone axis and line scan along the [100] direction (200 keV electrons, probe aperture 50 mrad, detector semi-angle 10 mrad, energy window 40 eV).

References