Type of presentation: Poster

IT-16-P-2950 The partial spatial coherence function and the distribution of scattered electrons

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The development of aberration correctors has made images with sub-Ångstrom spatial resolution in scanning transmission electron microscopy (STEM) routinely possible, greatly advancing our knowledge of the relationships between a material's atomic structure, composition, and its properties. It has been noted, however, that possessing atomically-resolved features does not guarantee an image can be quantitatively analysed column-by-column, especially for inhomogeneous materials [1,2]. The mechanism limiting our ability to attribute the spatial origin of the signal to specific atomic sites is the spreading of the electron probe as it travels through the specimen. The finite effective source profile, also referred to as the partial spatial coherence function, has been reported to have a large impact on the intensity distribution in STEM images [3,4]. However, the consequences of the effective source distribution for the spreading of the electron probe have not been much explored.

We investigate the implications of the partial spatial coherence function for quantitative analysis in STEM, especially for interpreting the spatial origin of imaging and spectroscopy signals. In particular, we examine how the shape of the source distribution, especially the length of its “tails”, influences the degree to which the electron probe scatters onto adjacent atomic columns. This was explored via the use of three different source distribution models applied to a GaAs crystal case study. The shape of the effective source distribution was found to have a large influence not only on the STEM image contrast, but also on the distribution of the scattered probe through the specimen and hence on the spatial origin of the detected electron intensities.

This has implications for our ability to extract column-by-column information via annular dark field, X-ray and electron energy loss STEM imaging, as precise knowledge of the spatial origin of the measured signal is a prerequisite for any high precision determination of structure, bonding and chemical composition at the atomic scale.

References

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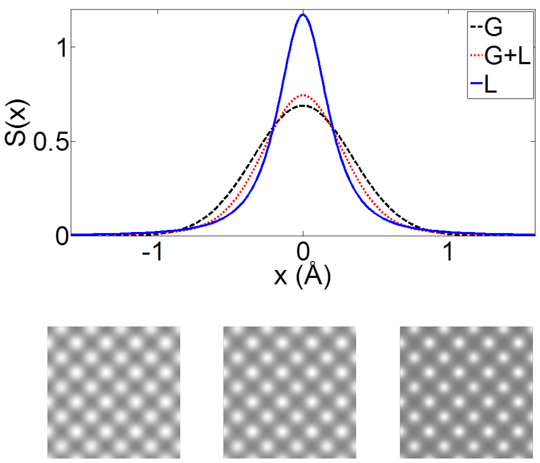

Fig. 1: Comparison between a Gaussian (G), Gaussian + Lorentzian (G+L) and Lorentzian (L) source profile, with the FWHM chosen to give a 60% reduction in contrast with respect to a coherent probe. The resultant ADF-STEM images are shown below it (from left to right: Gaussian, Gaussian + Lorentzian, Lorentzian)

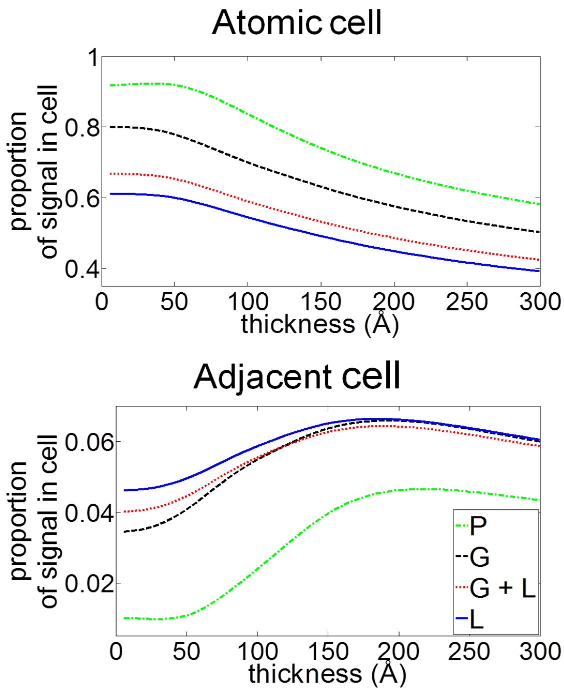

Fig. 2: The proportion of ADF signal generated from a single Ga atomic column in GaAs <001> recorded in a Voronoi cell around the column (top) and in an empty cell immediately adjacent to it (bottom). P refers to a diffraction-limited probe. G, G+L and L correspond to a Gaussian, Gaussian + Lorentzian and Lorentzian effective source, respectively.

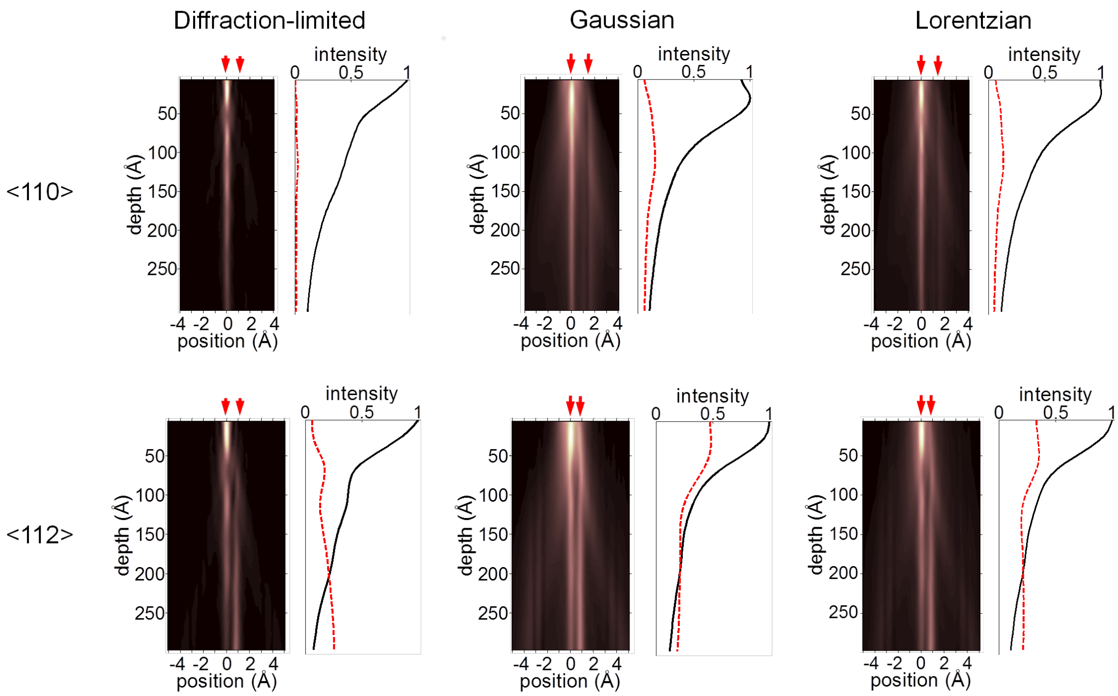

Fig. 3: Cross-sectional intensity map of the scattered probe (using three different source profiles) through a GaAs crystal of <110> and <112> orientation, and the corresponding plot of the normalised probe intensity on the Ga atomic column (integrated within a radius of 0.5 Å). The arrows point to the centre Ga column and the closest As column.