Evaluation of different rectangular scan strategies for HRSTEM imaging

Scanning transmission electron microscopes (STEMs) equipped with spherical aberration correctors are well known for their ability to obtain images with atomic scale information. The conventional ‘raster’ method scans the probe over the sample line by line. HRSTEM (High resolution STEM) imaging is typically performed by scanning a focused electron probe over a sample at sub-Ångstrom resolution. At such high resolution images, distortions are commonly present because of drift of the sample/stage during raster scanning, predominantly affecting the so-called ‘slow scan direction’ [1].

Making use of a programmable scan engine, here we investigate and compare three different scan patterns. We compare the typical raster scan with a so-called ‘snake’ pattern where the scan direction is reversed after each scan line and a novel Hilbert scan pattern [2] that changes scan direction rapidly and provides a more homogeneous treatment of both scan directions. We experimentally evaluate the imaging performance on a single crystal test sample (SrTiO3) by varying dwell time and evaluating behavior with respect to drift.

We demonstrate the ability of the Hilbert scan pattern to more faithfully represent the high frequency content of the image in the presence of drift. It is also shown that Hilbert scanning provides reduced bias when measuring lattice parameters from the obtained scanned images while maintaining similar precision in both scan directions which is especially important when e.g. performing strain analysis. Compared to raster scanning with flyback correction, both snake and Hilbert scanning also benefit from dose reduction as only small probe movement steps occur.

References

[1] S. Ning et al, Ultramicroscopy 184 (2018), p. 274.

[2] D. Hilbert, Math. Ann. 38 (1891), p. 459.