Aberration-corrected STEM: How far have we come and where are we going?

P.D. Nellist¹, N. Dellby², O.L. Krivanek², M.F. Murfitt² and Z.S. Szilagyí²

¹ Trinity College, College Green, Dublin 2, IRELAND.
² Nion Co., 1102 8th St., Kirkland, WA 98033, USA.

It is almost ten years since the start of a project to develop a spherical aberration corrector for a dedicated scanning transmission electron microscope instrument. Remarkable progress has been made since the first images that showed weak 2.35 Å lattice planes [1]. Dedicated STEM instruments (manufactured by VG Microscopes) fitted with Nion aberration correctors have demonstrated sub-1 Å resolution at 100 kV [2] and approaching 0.6 Å resolution at 300 kV (Fig. 1)[3]. We will review the technological developments that have made this progress possible.

The experience gained by aberration-correction of existing microscopes has been invaluable in the development of a new STEM column optimized for the use of aberration-correction. The development of a new column has created the opportunity to develop a new aberration corrector that can correct axial aberrations up to and including all 5-th-order aberrations. This new generation corrector will have 7-th-order axial aberrations of around 0.5 m as the lowest-order uncorrected aberrations, but performance is likely to be limited by chromatic aberration. Calculations show that the semi-angle of the probe-forming converging beam will be greater than 50 mrad, and spatial resolutions around 0.4 Å possible at 200 kV.

The existence of such instrumental capabilities creates many new applications opportunities in materials science, and these will be discussed.

Fig. 1. An annular dark-field STEM image (left) of Si<112> showing the 0.78 Å spacing between atomic columns well resolved. The Fourier transform of the image (right) shows the (444) lattice planes as expected, and also transfer up to the (804) lattice spacing at 0.61 Å.

References
[4] The authors would like to acknowledge M.F. Chisholm, A.R. Lupini, A. Borisevich, W.J. Sides Jr. and S.J. Pennycook for their collaboration in obtaining the data shown in Fig. 1.