Title
Towards half-Angstrom resolution: From One Angstrom Microscope to TEAM

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Publication Date
2003

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Sub-Ångstrom resolution is important for nanotechnology. Metal atoms can be routinely imaged in TEM specimens at resolutions from 2Å to 1.5Å. Better resolutions (~1Å) are required to "see" lighter atoms such as carbon [1], nitrogen [2] and lithium [3]. Once C_S is corrected, microscope information limit controls resolution. The one-Ångstrom microscope (OÅM) project at LBNL has demonstrated the capability of 0.78Å resolution at 300keV [4]. The Transmission Electron Achromatic Microscope (TEAM) is proposed [5] to reach resolutions of 0.5Å using hardware correction of C_S [6], a monochromator (to reduce electron-beam energy spread and improve its information limit beyond that of the OÅM), and chromatic aberration correction to allow a range of electron energies to be focussed together.

Methods employed in design and implementation of the successful OÅM project [1] can be used to determine appropriate parameters for the TEAM [7]. Calculations show that a C_C corrector is <u>not</u> required for TEAM to reach 0.5Å at 300keV or 200keV, provided that energy spreads can be reduced to 0.4eV and 0.2eV respectively. These values allow substantial beam current. At lower voltages, TEAM would require stricter limits on energy spread to reach the targeted 0.5Å resolution. No improvement in HT stability is required to improve the information limit *per se* since the monochromator determines the energy spread in the beam. However, improved HT will improve the beam current statistics (number of electrons passing through the monochromator) by placing more of the electrons closer to the center of the energy-spread distribution [8].

[1] M.A. O'Keefe et al., *Ultramicroscopy* **89** (2001) 4: 215-241.
[2] C. Kisielowski et al., *Ultramicroscopy* **89** (2001) 4: 243-263.
[3] Yang Shao-Horn et al., *Nature Materials* (in press).
[4] M.A. O'Keefe, E.C Nelson, Y.C Wang & A. Thust, *Philosophical Mag. B* **81** (2001) 11: 1861-1878.
[5] B. Kabius, C.W. Allen & D.J. Miller, *Microscopy & Microanalysis* **8** (2002) 2: 418-419.
[6] M. Haider, G. Braunshausen & E. Schwan, *Optik*, **99** (1995) 167-179.
[7] M.A. O'Keefe, NTEAM meeting (May 20, 2002) and NTEAM Workshop (July 18-19, 2002), LBNL.
[8] Work supported by the Director, Office of Science -- through the Office of Basic Energy Sciences, Material Sciences Division, U.S. Department of Energy, under contract No. DE-AC03-76SF00098.