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Correlative Microscopy: Progress in Simultaneous Atomic-column XEDS and EELS, using a Monochromated, Aberration-corrected STEM

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Analytical electron microscope development shows that the trend in electron gun design has been towards brighter emission with less energy spread [1]. Aberration correction on a thermal FEG system has many well-known and demonstrated advantages over non-corrected electron microscopes both for TEM and STEM applications. The combination of a probe Cs correction and an electron source monochromator yields a further step along the path to an ideal microscope. The further benefits of monochromator integration are for applications that especially depend on energy resolution such as spectroscopy and advanced contrast mechanisms such as “atomic scale” energy filtered imaging, Figure 1 (left).

The addition of a probe corrector allows the illumination aperture size to be increased and provides significant increases in the beam current for the same probe size [2]. There has been much work in the improvements of STEM technology for the applications of atomic resolution HAADF, column stability being of critical importance (Figure 2, right). Other features such as new improvements of collection optics of the spectrometer entrance aperture and minimizing the elastic scattering artifacts [3,4], further improve the ability to perform atomic-column EELS imaging.

One feature of most modern analytical electron microscopes is the energy dispersive X-ray (XEDS) detector, whose basic application on modern instrumentation has not changed since the early days of analytical TEM’s. But the fundamental concepts of energy dispersive X-ray analysis are still important for modern analytical microscopy; the most important for the collection of X-rays is, of course, the solid angle of the detector with respect to the sample, the collection efficiency of the detector roughly scaling with the solid angle. The limited space around the microscope pole piece in a STEM make it a difficult task to improve solid angle and yet still retain imaging performance. By using an old idea in this new setting of an aberration corrected instrument we have increased solid angle by using twin detectors on a modern monochromated, Cs probe corrected column as shown in Figure 2 (left). The two detectors are mounted exactly 180 degrees with respect to each other and as close to the sample as practically possible. In this configuration the sample is not tilted and maintains the correct perspective relative to HAADF and energy-loss spectroscopy analysis Figure 2 (right). This system brings closer the realization of atomic scale XEDS imaging with increased x-ray collection.

Probe aberration-correction, monochromator, in-column energy filter and advanced x-ray detection sensitivity combined on one analytical platform provide a foundation for correlative microscopy using simultaneous signal collection as an approach towards the realization of simultaneous atomic-column EELS and XEDS analysis.

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References
[1] P.W. Hawkes and J.C.H. Spence *Science of Microscopy* Springer (2007)
[2] P.E. Batson, N. Delby, O.L. Krivanek, Nature **418**, 617 (2002)
[3] D.A. Muller et al, Science 319:1073–1076. (2008).
[4] S.J. Pennycook, et. Al., J. Electron Microsc. (Tokyo), January (2009)
[5] The authors wish to thank Brent Hammell , Alan Sandborg, Del Redfern, Russ Smith and Judy O'Loughlin of EDAX Inc. for their support with this project.

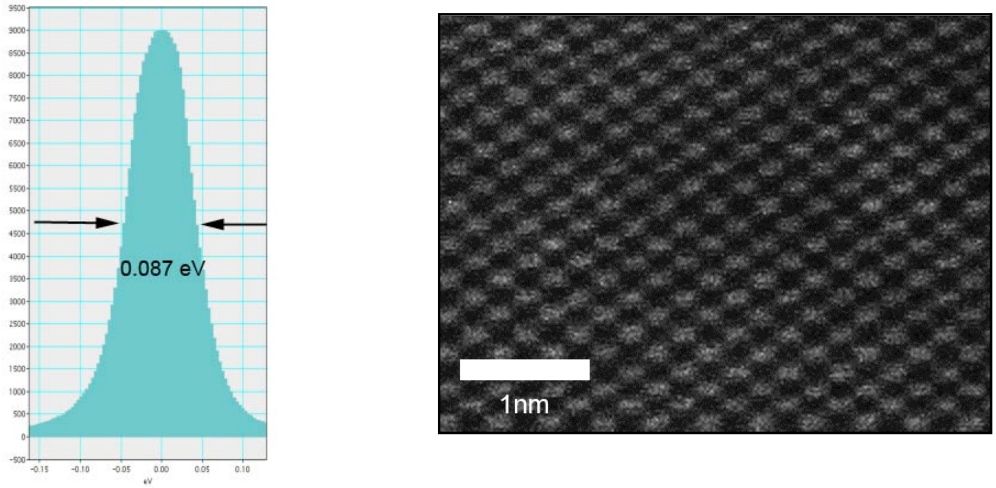

Figure 1. Left, tuned energy spread available from the monochromator on the Zeiss Libra 200 aberration-corrected STEM platform. Right, the standard Cs-corrected STEM test the aberration-corrected HAADF image of Si [110] dumbbells indicating overall platform stability.

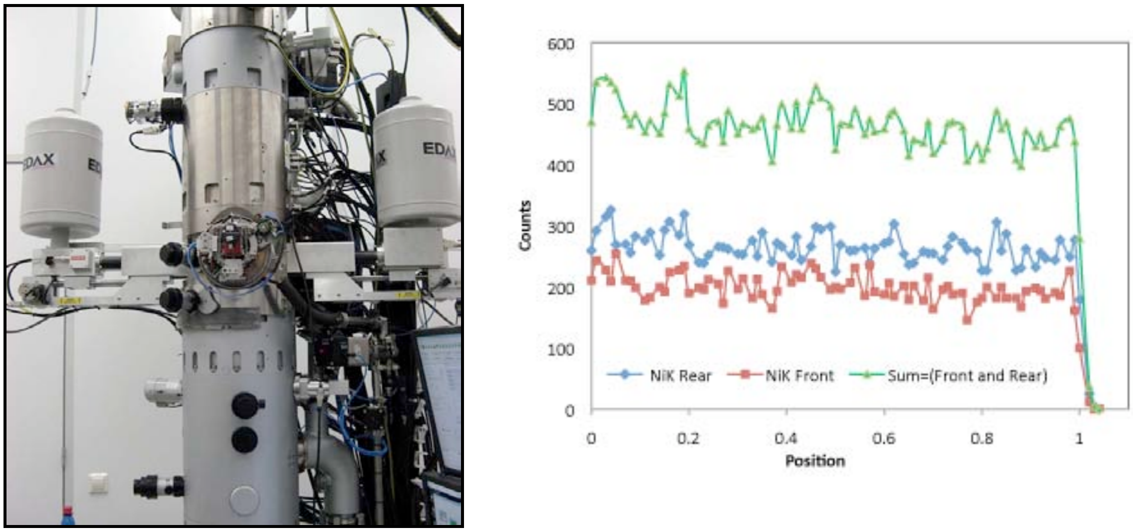

Figure 2. Left, twin 180 degree offset (symmetrical to sample) XEDS detectors mounted on a probe Cs corrected column. Right, preliminary test linescan across a Ni thin film edge indicating the increase in gain, further tuning will be performed.

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