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Using STEM Image as a Map for Parallel Beam Electron Diffraction from a Nano-Particle on a TEM-STEM system

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It is now well known that with diffraction intensity and additional information in real space one can reconstruct the real space images using iterative phase retrieval algorithms such as hybrid input output (HIO) [1]. The insensitiveness of diffraction to vibration, aberration makes the potential resolution much higher than conventional high resolution electron microscopy (HREM) method using a lens where it is unusual to go beyond 1 Å. This opened a new way to obtain aberration free images on a TEM without expensive aberration correctors.

The diffraction pattern used in this method is obtained with a small diameter parallel beam illumination in order to fulfill the oversampling requirement [2]. Though selected area diffraction is the widely used method to limit the effective diffraction area, it has intrinsic problems due to the spherical aberration of objective lens which will affect the resolution limit one can achieve. Therefore the best approach is using condenser aperture to limit the illumination as chosen by previous two reports [3,4]. However, to select a particular nano-particle for subsequent studies could be challenging and time consuming. Here we describe a method that eases the task by taking advantage of the STEM functionalities on a modern TEM-STEM system that can visually locate the beam onto a specific interested object.

The experiment was performed on a recently installed Zeiss Libra 200 kV field emission TEM-STEM Omega instrument at NCEM (LBNL). Libra's Koehler mode design when working with a small illumination aperture provides ~50nm diameter parallel beam. In addition, Libra is fitted with an Omega imaging filter (and monochromator), which provides elastically filtered diffraction patterns from which most of the background due to inelastic scattering has been removed.

The microscope was working under STEM mode. A STEM scanning image was obtained first with the smallest condenser aperture which is ~5 μm in diameter on Libra. Then the beam is changed to parallel beam mode by changing the final condenser lens focus (and therefore the crossover position above the objective lens). This avoided going out of STEM mode and the risk of breaking all lens and aperture alignments. On Libra, we found the final condenser lens defocus value of -65.6% corresponds exactly to a normal TEM mode (only the final condenser lens, not any other lenses are affected by such operation). With good alignment, the beam can now be positioned onto any object on the pre-scanned STEM image by setting the beam to still mode (in contrast to scanning mode, on Libra, it's called "Spot mode" under STEM operation).

As a demonstration of the above method, we used Au nano particle deposited onto carbon film as the specimen. Figure 1a is the STEM image. Figure 1b is the HREM image showing the lattice image of the particle. Figure 1c is the diffraction pattern taken on the same object. Figure 1d is the square of the modulus of Fourier transform performed on Figure 1b. Figure 1c and 1d compares very well except a rotation and constant scaling.

References

[1] J. R. Fienup, *Applied Optics* **21** (1982) 2758.
[2] J. Miao, J. Kirz, and D. Sayre, Acta Crystallographica Section D-Biological Crystallography **56** (2000) 1312.
[3] J. M. Zuo, I. Vartanyants, M. Gao, R. Zhang, and L. A. Nagahara *Science* **300** (2003) 1419.
[4] Wu, J. Weierstall, U., and Spence, J.C.H. *Nature Materials*, **4** (2005) 912
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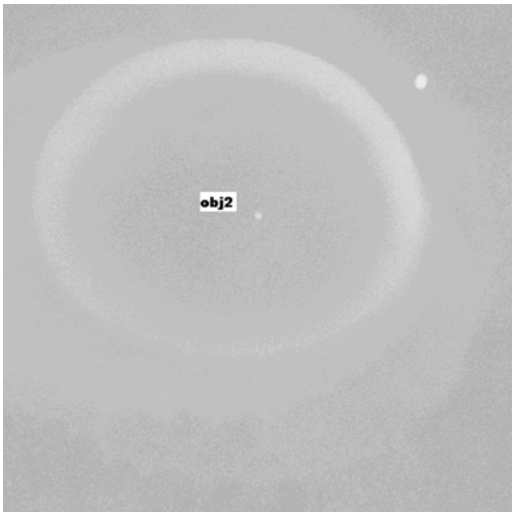
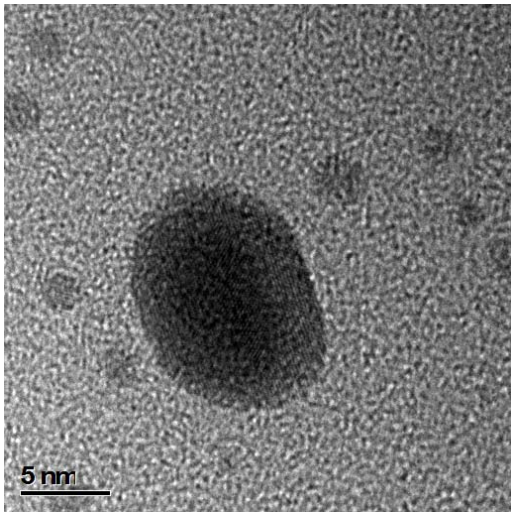
FIG. 1a. STEM image of gold particles on Carbon film coated copper grid. The particle labeled with obj2 is used in later studies with HREM and diffraction; **1b.** HREM image of obj2; **1c.** Diffraction pattern of obj2; **1d.** Modulus of Fourier transform of image in **1b**.

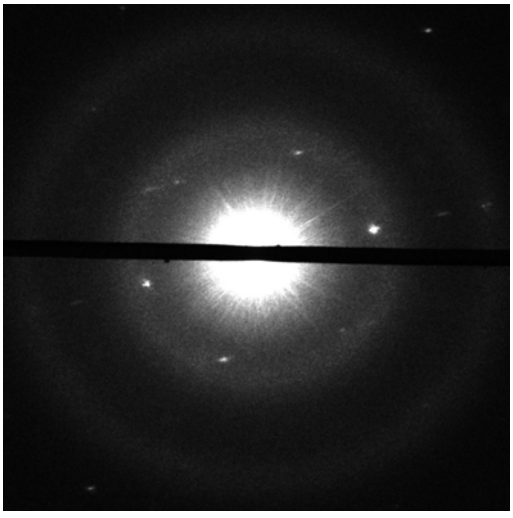
1a.



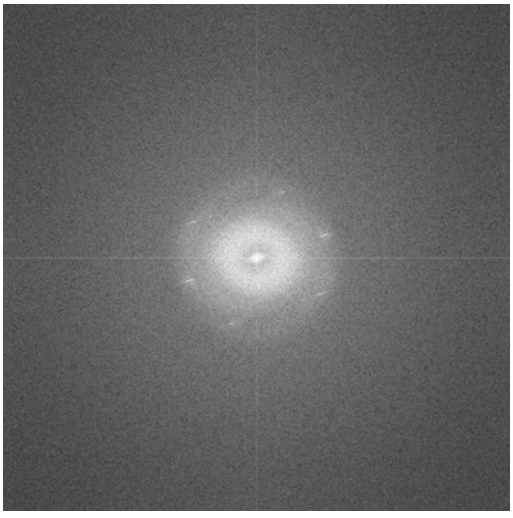
1b.



1c.



1d.



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