Single Atom Scattering/Diffraction Measurements using a Pixelated Array Detector

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Pixelated detectors which facilitate position resolved diffraction (PRD) have been available for more than 15 years and have been applied to both diffraction and imaging [1-2] with implementations employing virtual apertures and digital reconstruction to enabled off-line interrogation of complex scattering phenomena [1,3]. The limited application of PRD todate has been related to a combination of both acquisition time and detector dynamic range which in a practical sense are simply hardware issues. The advent of high speed, high dynamic range pixelated array detectors married to the new generation of aberration corrected instruments have facilitated a revival of PRD (also termed 4D STEM)experiments which were impractical in the past [4]. In this work we present initial study of scattering from single atoms of Pt, which have been judiciously deposited upon ultrathin "holey" nanocrystalline diamond which provide both support and calibration. These measurements were conducted using a Thermo Fisher Scientific Themis Z aberration corrected instrument operating at 300 kV, with a prototype 128x128 pixel EMPad system [5]. The focused probe was scanned over a 64x64 pixel region at ~ 1 msec/pixel, and employed a 30 mR, ~ 100 pm probe with beam current < 2 pA. In figure 1, we present the measurement of the scattering profile from a single atom supported on our ultra thin substrate. Reconstructed here are images and scattering profiles from a isolated Pt atom (1A, 1B), as well as a nearby ultra thin region (1C,1D) of the support film. In reconstructing the position resolved scattering profiles a 3x3 pixel virtual aperture located at the position marked by the arrows was used as an integration unit. Figure 1E presents the radially averaged intensity profile (log scale) for the delineated areas of (1 B & 1D). The most serious limitation to this work is presently related to atomic motion of loosely bound atomic species on the support surface. Over the course of hours only a limited number of Pt atoms remain motionless during the 1 msec/pixel exposure. Work is currently in progress to test mitigation strategies using cooling holders.

References

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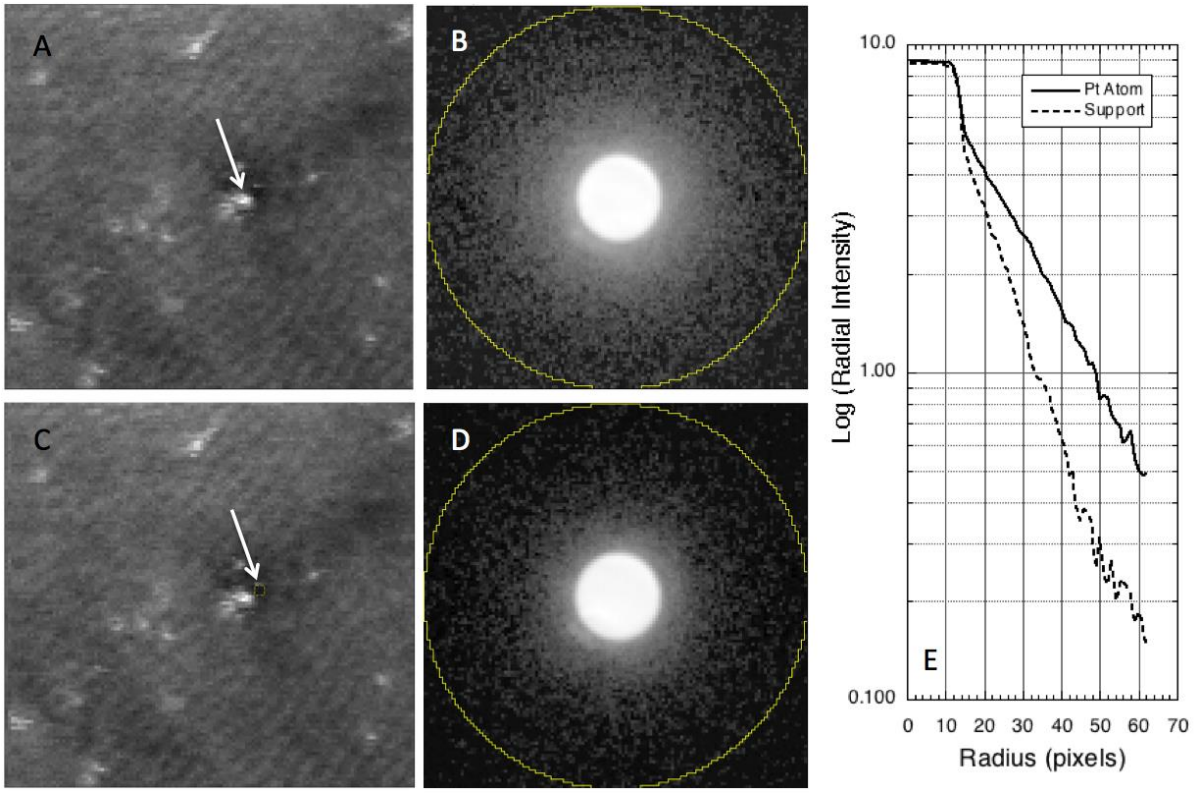

Figure 1. Experimental images and scattering patterns recorded from a Single Pt Atom (A,B) compared to on a ultra thin, nanocrystalline diamond support (C,D). The log scale PRD patterns (B,D) are a reconstruction using a 3x3 virtual aperture shown at the location indicated by the arrows in A, C respectively.), Radially averaged intensity profiles are shown in 1E.