Transmission Helium Ion Microscopy

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The Helium Ion Microscope (Zeiss Nanofab) provides a focussed He+ ion beam (20 - 35 keV) that is finding applications in nanoscale milling and patterning, and surface-sensitive secondary electron imaging. The imaging column features an atomic-scale, field-emission source that enables a focused probe size of less than 1 nm, with beam currents of 0.01 – 100 pA. The localized source also means that the beam is spatially coherent and can therefore, potentially, provide image contrast from channeling and diffraction, similar to transmission electron microscopy. The detection of transmitted ions through thin samples has been reported via secondary electron emission from a phosphor screen excited by a scanned He beam [1].

In this work, the addition of an x-ray camera (Modupix) underneath the sample stage consisting of an array of Si p-i-n diodes (pixel spacing 55 microns) has allowed the first direct detection of focused and scanned He beams. The spotsize and uniformity of the beam profile as a function of aperture, and lens conditions has been directly measured. The transmission through thin films (Si, Al, C and polymers) of scanned and divergent beams has been imaged with a lateral resolution of 5 microns, limited by the detector resolution and distance below the sample (15 cm). Figure 1 (a) shows a diagram of the experimental set-up, (b) a secondary electron image and (c) an image generated by the transmission of the neutral He beam component (0.5 fA current) through a poly-Si sample on a Cu grid. Plot (d) shows a count profile along the rectangle in (c). The neutral He beam develops due to interactions of the ion beam within the ion column, and is shifted here from the primary ion beam by 150 microns. The detection of ion milling rates, diffraction and channeling will be discussed.

[1] Diffraction Imaging in a He+ Ion Beam Scanning Transmission Microscope
John Notte, Raymond Hill, Sean M. McVey, Ranjan Ramachandra, Brendan Griffin, and David Joy, *Microsc. Microanal*. **16**, 599–603, 2010.

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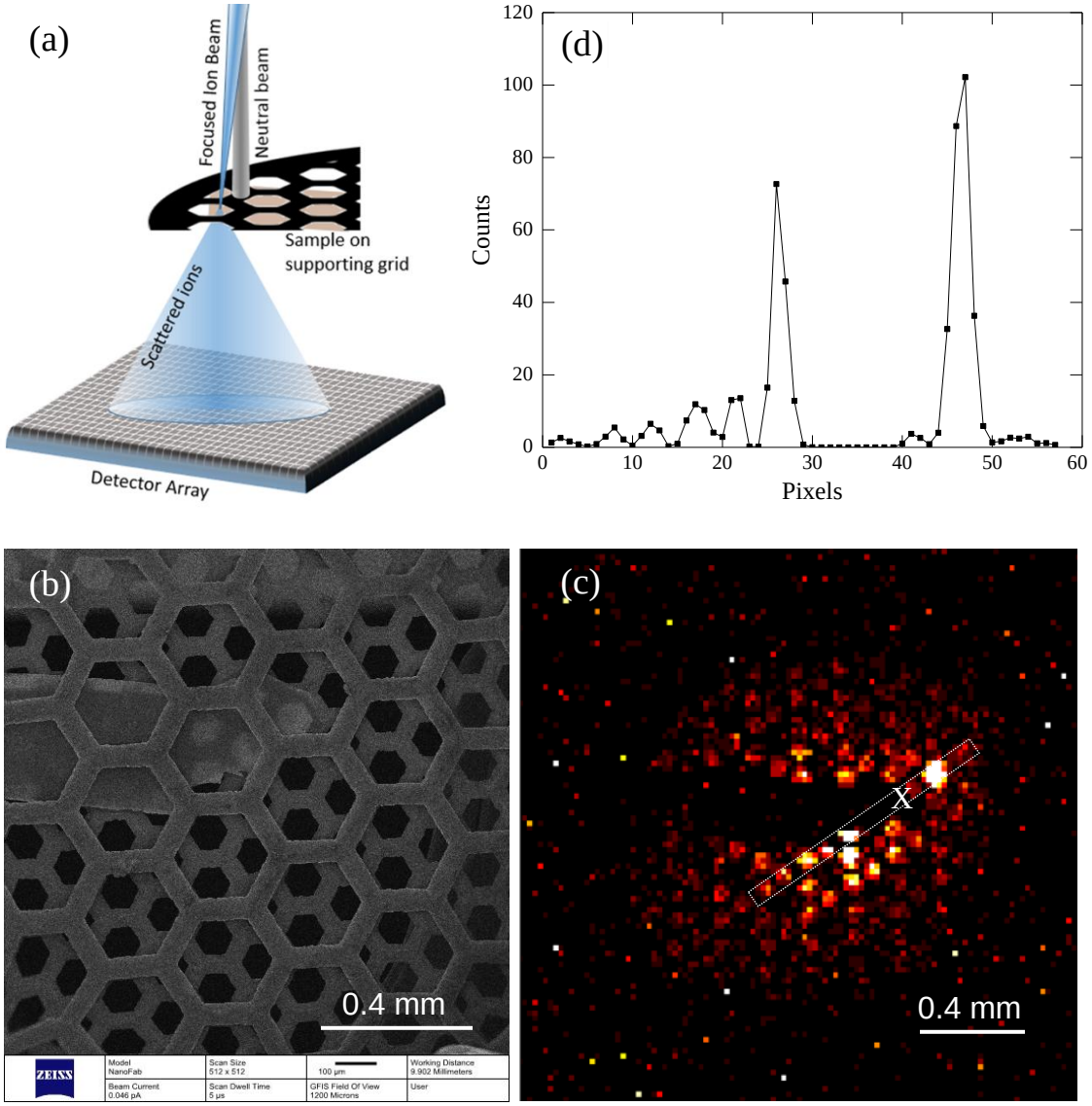

Fig. 1: (a) Diagram of the experiment showing the direct He detector array underneath the sample (15 cm) in a He ion microscope (Zeiss, Nanofab). (b) Secondary electron and (c) THIM images. The sample is a folding Cu TEM grid (3 mm diameter) with a poly-Si film (90 nm) covering part of the grid area. (d) Count profile along the rectangular area in (c). Pixels are 55 micron spacings. The primary He beam (50 fA) was deflected (blanked) leaving the much weaker neutral beam centered at position X and covering a wide area of the sample. Total counts: 1 (red) - 150 (white). Exposure time: 500 s.