High-Resolution 3D Ptychography of a Tempered UO_2/Mo-Film

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The hard x-ray nanoprobe of beamline P06 at PETRA III allows one to perform high-resolution 3D-ptychography. Three-dimensional ptychography combines two techniques, ptychography and tomography and, therefore, takes advantage of both the high penetration power of hard x-rays and the high sensitivity of lensless imaging [1-4]. In principle, the spatial resolution is only limited by the fluence on the sample and ultimately by the wavelength of the x-ray photons [5]. In this experiment the dose density is maximized by nano focusing [6]. We applied this technique to a sample consisting of a thin UO_2/Mo film sputtered on a SiO_2 substrate and a carbon layer deposited on the top of the uranium film. Figure 1a) shows a SEM image and a schematic sketch of the sample.

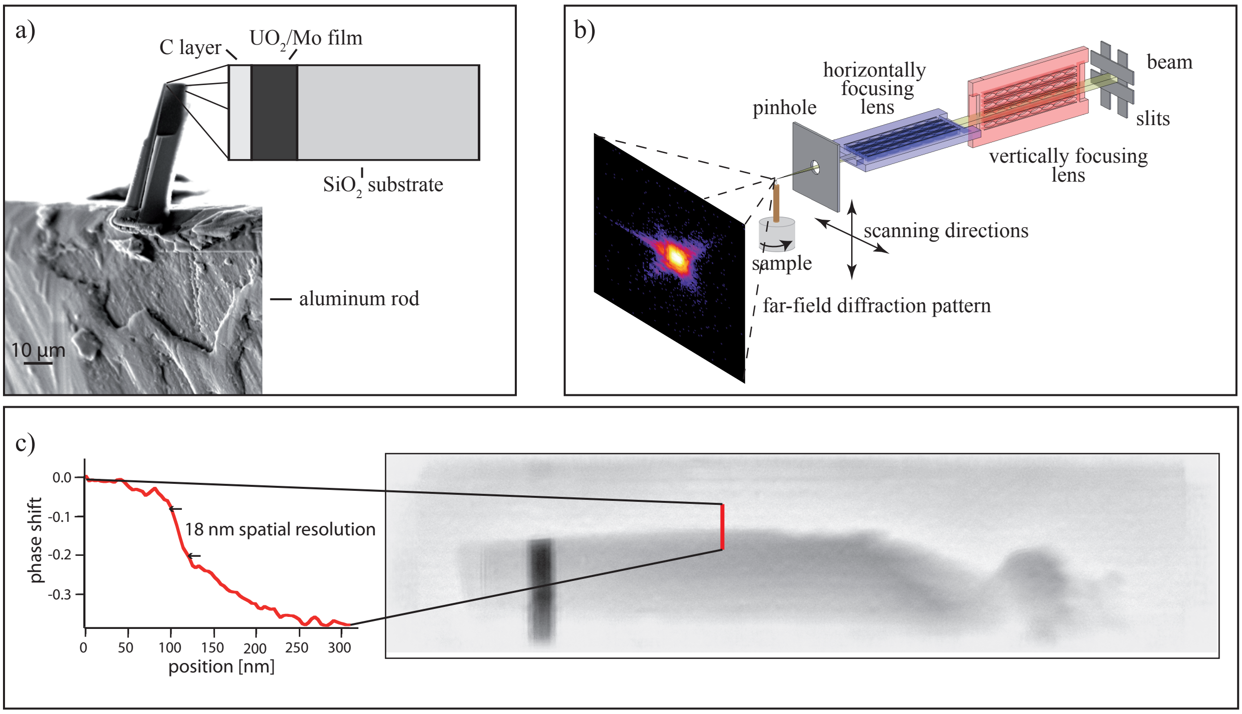

Figure 1: a) SEM image of the sample together with a schematic sketch. (b) Experimental setup for 3D ptychography. (c) Ptychographic reconstruction at angular position 108°. The spatial resolution is about 18 nm.

A tomographic data set consists of a sequence of projections measured at different angular positions. In this experiment, each projection is generated via ptychography. That is, at each angular position of the tomogram, the sample was scanned trough a transversely modulated beam and at each position of the scan a far-field diffraction pattern was recorded (compare Figure 1b)). From the diffraction patterns and by means of the knowledge of their positions in the scan, the transmission function of the object and the complex illuminating wave field was reconstructed simultaneously

[2, 3]. The two-dimensional high-resolution projections obtained in this way were used in the following tomographic reconstruction to produce a three-dimensional image of the internal structure of the sample [7-11]. We measured ptychograms at 91 angular positions uniformly distributed over 180°. Figure 1c) shows the ptychographic reconstruction at the angle of 108° as an example. The achieved spatial resolution is 18 nm. The 91 high-resolution ptychograms were the input for the tomographic reconstruction. Figure 2a) represents a reconstructed slice through the sample. This reconstruction of the local refractive index decrement has a resolution similar to that in the individual projections (compare Figure 2b)).

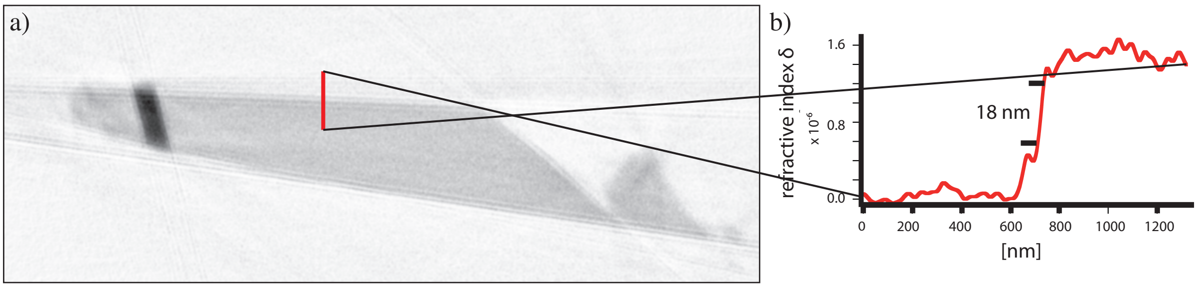

Figure 2: a) Tomographic reconstruction of one single slice trough the sample. (b) The local spatial resolution of the refractive index decrement δ is about 18 nm.

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