

Multiple slit interference and diffraction

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The recent advances in nanotechnology and electron microscopy are making today possible the realization of experiments of diffraction and interference at multiple slits which formerly were carried out with extremely skilled specimen preparation techniques and dedicated electron optical apparatus [1]. Recently we have used the focused ion beam (FIB) to fabricate two slits on a commercial silicon nitride membrane suspended on a $100 \times 100 \mu\text{m}^2$ window realized on a $200 \mu\text{m}$ thick silicon substrate, and observe the Fraunhofer image in a conventional TEM-JEOL 2010 [2].

Here we adopt a less expensive support for nano slits fabrication, consisting of a commercial continuous carbon film on a standard copper grid, which was subsequently evaporated with a gold layer about 120 nm in thickness. The slits (nominally 80nm wide, 420 nm spaced) were fabricated with a 9 pa, 30keV, Ga^+ beam of a FEI Strata235M dual beam. The quality of the slits is really excellent, as shown in Fig. 1, which displays two (a), and three (b) slits. An additional advantage of these samples with respect to the previous $200 \mu\text{m}$ thick ones, is that they can be inserted in almost all TEM-FEG specimen holder.

The diffraction and interference experiments were carried out with the FEG-TEM JEM-2200FS. Owing to the larger coherence of the FEG with respect to the thermionic source, it has been possible to record interference and diffraction images with exposure times of few seconds.

The three-slit case is illustrated in Fig. 2: (a) shows the image in focus, (b-d) the images taken at a nominal defocus of -10 mm, -20 mm and -40 mm respectively. They show the transition from the nearly separated Fresnel diffraction images of the single slits (b), to their subsequent overlapping as the defocus increases (c), displaying interference phenomena, till (d) the transition to a nearly Fraunhofer image.

Fig. 3 displays the true Fraunhofer image, taken at a nominal defocus of -53 mm, which clearly shows the secondary minima between the more intense maxima. In the same figure in the perpendicular direction the single slit Fraunhofer images corresponding to the longer side of the slits can also be observed.

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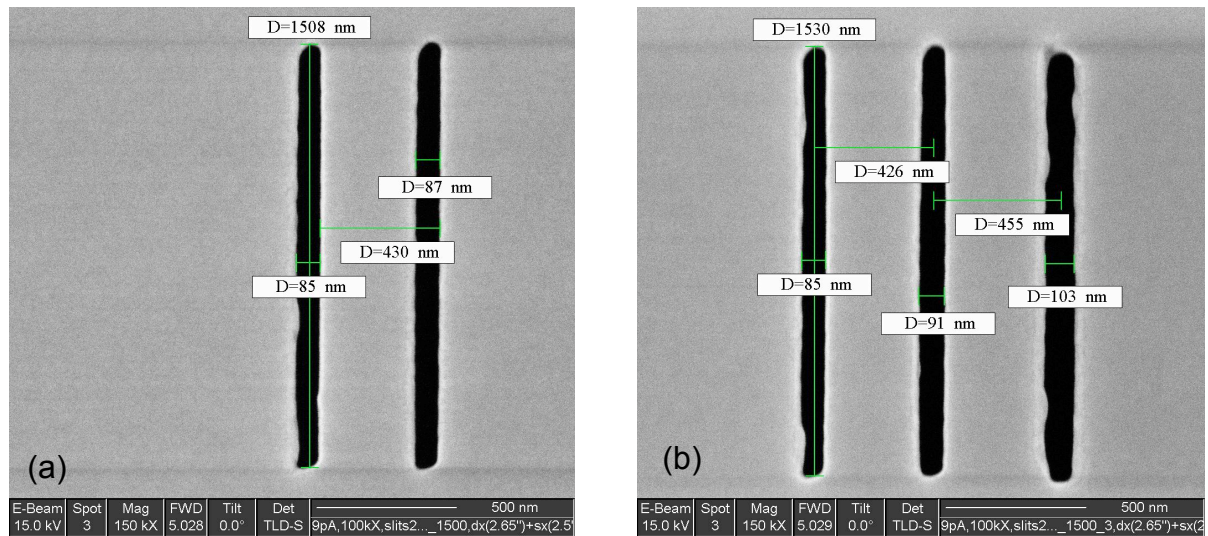


Figure 1. SEM images of the two (a) and three (b) slits fabricated by FIB.

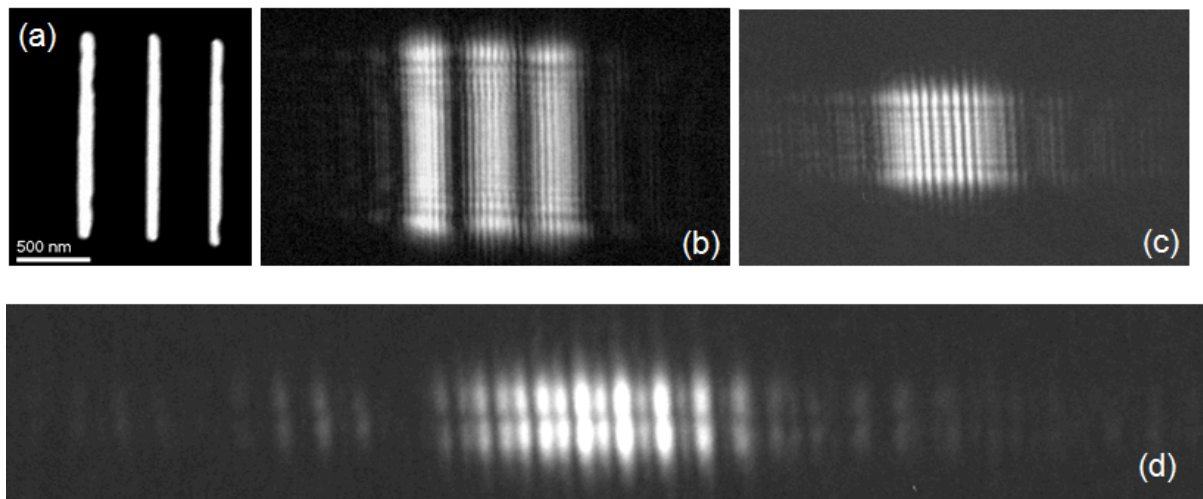


Figure 2. Through focus series of the three slits showing the transition from Fresnel to nearly Fraunhofer image. (a) $\Delta f \approx 0\text{mm}$. (b) $\Delta f \approx -10\text{mm}$. (c) $\Delta f \approx -20\text{mm}$. (d) $\Delta f \approx -40\text{mm}$

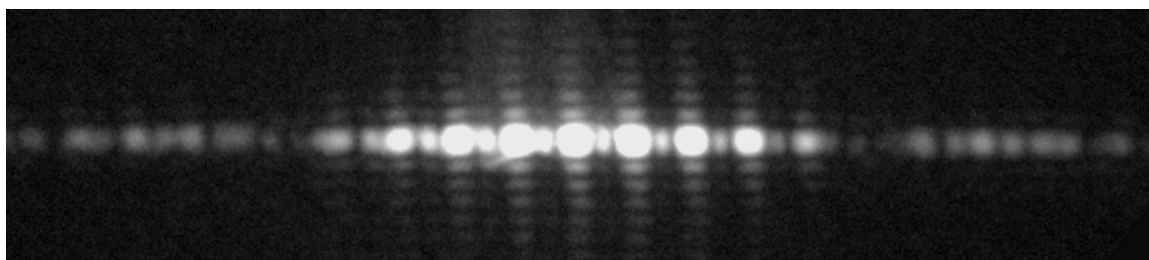


Figure 3. Fraunhofer image of the three slits taken at $\Delta f \approx -53\text{mm}$ which clearly shows both the secondary minima between the more intense maxima and the single slit Fraunhofer images corresponding to the longer side of the slits.