Multiple beam interference and diffraction with FIB fabricated nano-slits

S. Frabboni[1,2], C. Frigeri[3], G. C. Gazzadi[2], and G. Pozzi[4]

1. Department of Physics, University of Modena and Reggio Emilia, via G. Campi 213/a, Modena, 41100, Italy
2. CNR-INFM-S3, via G. Campi 213/a, Modena, 41100, Italy
3. CNR-IMEM Institute, Parco Area delle Scienze, 37/A, Parma, 43010, Italy
4. Department of Physics, University of Bologna, viale B. Pichat 6/2, Bologna, 40127, Italy

stefano.frabboni@unimore.it
Keywords: interference, diffraction, slits, FIB

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 (500 nm thick) suspended on a 100x100μm^2 silicon frame 200μm thick. In that case the Fraunhofer image was observed 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 coated 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 very good, as shown in Fig. 1(a) and Fig.1(b), that display two and three slits, respectively. An additional advantage of these samples with respect to the previous ones, is that they can be inserted in almost all FEG-TEM specimen holders.

The diffraction and interference experiments were carried out with a JEM-2200FS electron microscope. 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 where the in focus image (a), and the images taken at a nominal defocus of -10 mm (b), -20 mm (c) and -40 mm (d), are reported. This sequence shows the transition from the nearly separated Fresnel diffraction images of the single slits, (b), to their subsequent overlapping as the defocus increases, displaying interference phenomena, (c), and finally to a nearly Fraunhofer image, (d).

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 the single slit Fraunhofer images corresponding to the longer side of the slits can also be observed.

1. C. Jönsson, Z. Physik. **161** (1961) p454.
2. S. Frabboni, G. C. Gazzadi and G. Pozzi, Appl. Phys. Lett. **93** (2008) p073108

G. Kothleitner, M. Leisch (Eds.): MC2009, Vol. 1: Instrumentation and Methodology,
DOI: 10.3217/978-3-85125-062-6-140, © Verlag der TU Graz 2009

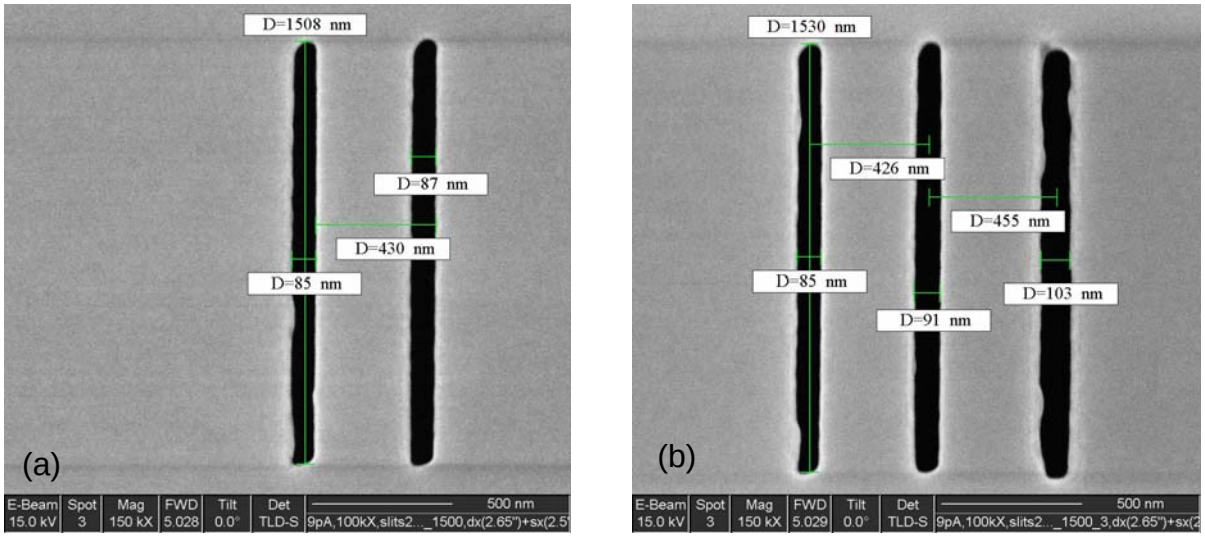

Figure 1. SEM images of the two (a) and three (b) slits fabricated by FIB.

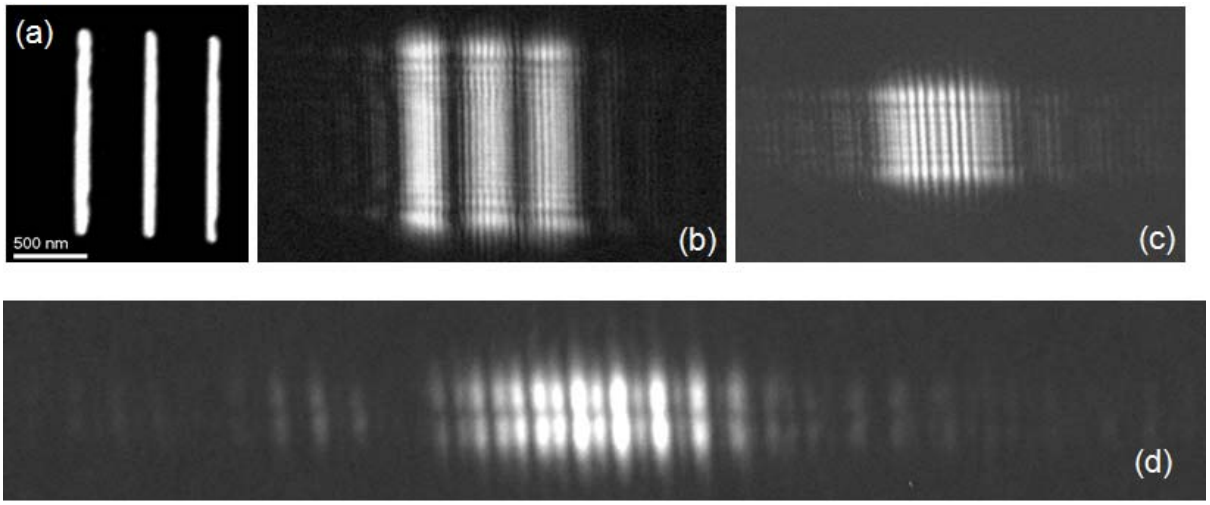

Figure 2. Through focus series of the three slits showing the transition from Fresnel to nearly Fraunhofer image. (a) $\Delta f \approx 0$mm. (b) $\Delta f \approx -10$mm.(c) $\Delta f \approx -20$mm. (d) $\Delta f \approx -40$mm

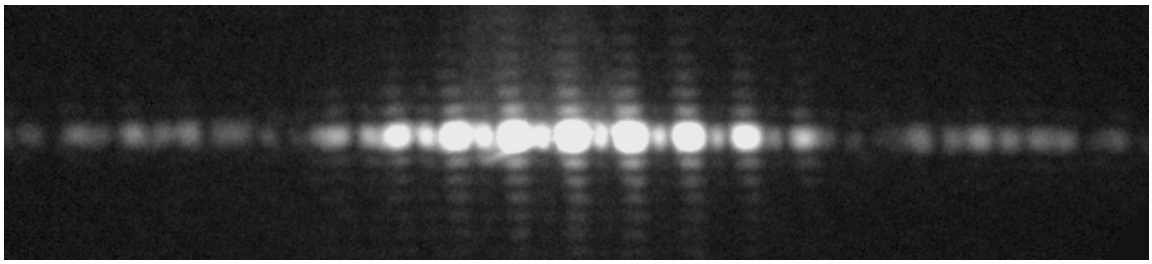

Figure 3. Fraunhofer image of the three slits taken at $\Delta f \approx -53$mm which clearly shows both the secondary minima between the more intense maxima and single slit Fraunhofer images corresponding to the longer side of the slits.

G. Kothleitner, M. Leisch (Eds.): MC2009, Vol. 1: Instrumentation and Methodology,
DOI: 10.3217/978-3-85125-062-6-140, © Verlag der TU Graz 2009