IM.5.P116
Fabrication and investigation of electrostatic condenser twin aperture for EMCD experiments

A. Pritschet[1], J. Zweck[1]

[1]Universität Regensburg, Physik, Regensburg, Germany

josef.zweck@physik.uni-regensburg.de
Keywords: EMCD, phase plate, aperture, simulation, beam cross-over

At the EMC2008 we have proposed a modified experimental setup [1] for overcoming the quality and orientation requirements in EMCD (Electron Magnetic Chiral Dichroism) [2] experiments. Our proposed changes to the setup are the exchange of a standard condenser aperture with a *twin aperture* (see Figure 1), which consists of two holes; each equipped with a ring electrode (Boersch phase plate [3]) allowing to adjust a phase difference between the transmitted beams.

Now we present a twin aperture prototype – together with a customized condenser aperture holder which is fabricated from a 25µm thick platinum foil. Figure 2 illustrates the fabrication process and Table 1 states the layer thicknesses. The choice for this substrate and thickness is based on the encounter of threefold astigmatism and other charging effects (see Figure 3) during the usage of thin (≤ 2µm) twin apertures fabricated from Si_3N_4 membranes. By means of Monte Carlo simulations of electron trajectories [4] the thickness of 25µm is determined to be sufficient for absorption of 200keV electrons in the Pt foil. Figure 4 shows the penetration probability derived from this simulation.

Furthermore we conduct theoretical and experimental investigations regarding the electron optical characteristics of these devices.

Using finite element simulations [5] we derive analytical models for the phase shift depending on the aperture plane coordinate and the applied potential at the ring electrodes. Using Fourier optics we investigate the wave function of a focused spot in the sample plane, which is the Fourier transform of the aperture function assuming an incident plane wave. The aperture function takes into account the aperture shape, our phase shift model and aberrations.

These calculations show that aberrations and deviations from a constant phase shift model [3] have negligible influences on the wave function in the sample plane in regions close to the optical axis (see Figure 5).

Using different experimental techniques we take a closer look on charging effects in thin twin apertures which we intend to avoid now by using a thick Pt-based device. After overcoming these effects we demonstrate the successful observation of an electron beam cross-over in the sample plane (Figure 6) with a diameter (=full width at half maximum) of ≈ 7nm. The cross-over shows no interference fringes as predicted by theory due to instabilities of the microscope.

1. A. Hasenkopf and J. Zweck, Proceedings of EMC 2008 – Late Breaking Posters (2008)
2. P. Schattschneider, S. Rubino, C. Hébert J. Rusz, J. Kunes, P. Novák, E. Carlino, M. Fabrizioli, G. Panaccione and G. Rossi, Nature 441 (2006), p. 486 – 488
3. T. Matsumoto and A. Tonomura, Ultramicroscopy 63 (1996), p. 5 – 10
4. D. Drouin, A. R. Couture, D. Joly, X. Tastet, V. Aimez and R. Gauvin, Scanning 29 (2007), p. 92 – 101
5. J. E. Guyer, D. Wheeler and J. A. Warren, Computing in Science & Engineering 11 (2009), p. 6 – 15

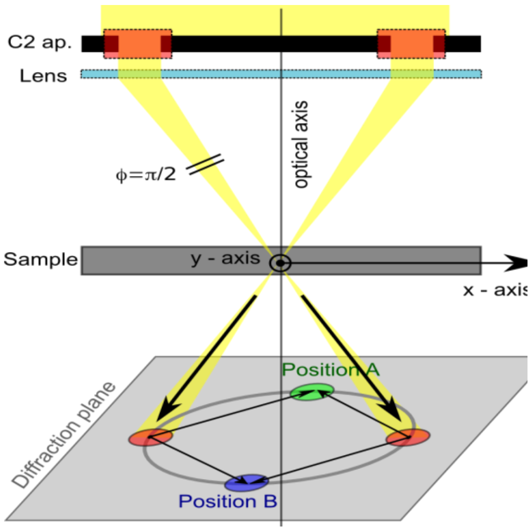

Figure 1. Schematic setup. Each aperture hole is equipped with a phase plate (red rectangle). The two transmitted beams by the aperture are equivalents to Bragg beams in the intrinsic method and define a Thales circle with measurement positions **A** and **B**.

Layer	Pt	SiO	Au	SiO	Au
Thickness [µm]	25	0.4	0.1	0.4	0.1

Table 1. Layer thicknesses of fabricated twin aperture.

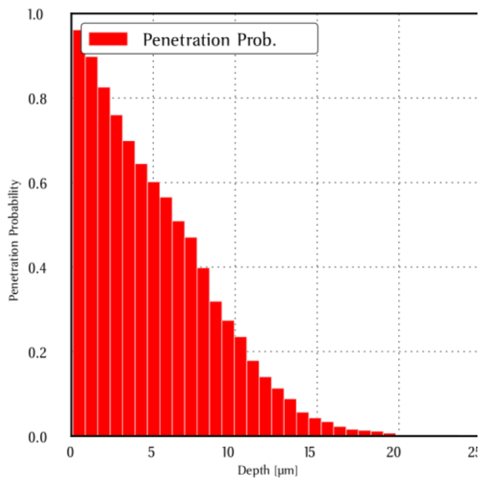

Figure 4. Penetration probability for 200keV electrons in platinum derived from electron trajectory simulations.

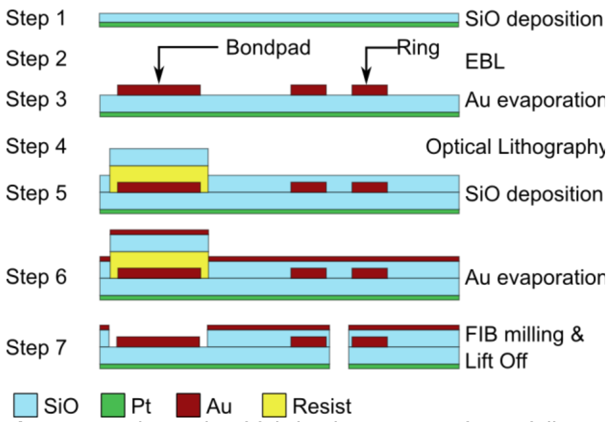

Figure 2. Schematic of fabrication process for Pt foil substrate (layer thicknesses not drawn to scale).

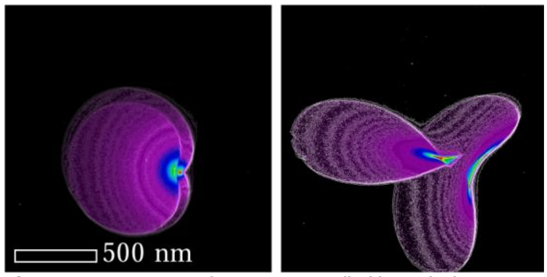

Figure 3. Images of cross-over (left) and close to cross-over (right). Charging effects introduce strong threefold astigmatism and increase spot diameter drastically.

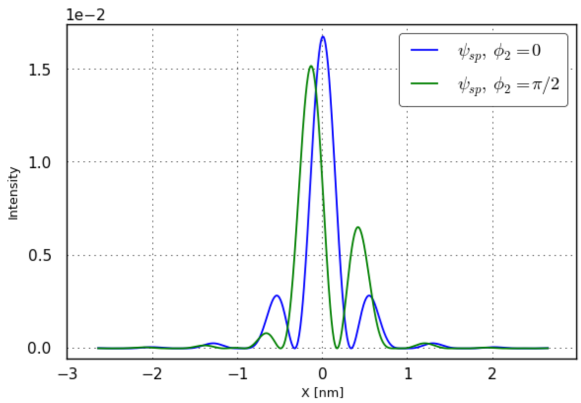

Figure 5. Theoretical prediction of cross-over in sample plane for 200keV electrons.

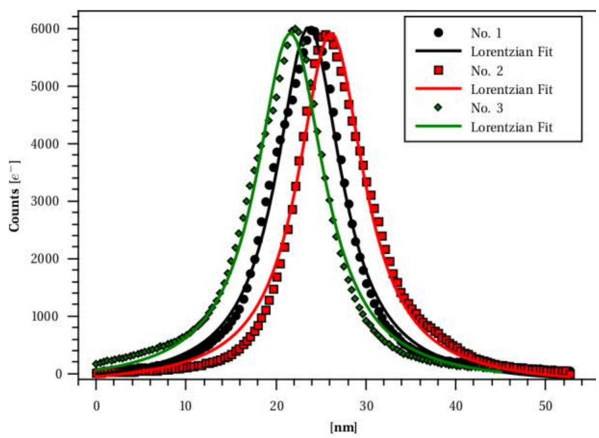

Figure 6. Cross sections across one acquired focused spot along different directions at 200kV. FWHM ≈ 7nm.