THE APPLICATION OF FRESNEL FRINGES TO THE DETERMINATION OF THE LOCAL FILAMENT DIAMETER IN AN ELECTRON BIPRISM

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Intensity distribution in a diffraction pattern of the electron diffraction at a filament depends to a great extent on its diameter. This is used for the determination of the filament diameter with an accuracy better than $2\%$. The described method is suitable e.g. for the determination of the local filament diameter in an electron biprism. Therefore the non-uniform diameter of filaments used in an electron biprism presents no difficulties in the interpretation of diffraction and interference patterns.

For the interpretation of the electron interference experiments performed with the use of an electrostatic Fresnel biprism a knowledge of the biprism filament diameter is necessary [3]. In view of the number of interference fringes in the interference region for a given filament potential it is advantageous to use a filament diameter as small as possible. This is why we used metal-plated spider's threads in our experiments. The observation of these threads in an electron microscope has shown that their diameter is usually not constant all over their length, but it may vary by as much as $20\%$ on a length of 20 $\mu$m. This makes the determination of the local filament diameter difficult; by the local filament diameter we mean the diameter in the place where the electron beam is split by the biprism filament.

In our preceding paper [2] we showed that the intensity distribution in a diffraction pattern at zero potential of the filament depends very sensitively on the filament diameter. By analysing the diffraction pattern it is possible to determine the local filament diameter with high accuracy.

Our experiments were performed with an electron microscope modified for interference electron microscopy. The experimental arrangement has recently been described [1, 2] and therefore only the most important parameters are quoted here: distance of the line source from the filament $a = (146.0 \pm 0.6) \text{ mm}$, distance of the filament from the plane of observation $b = (31.0 \pm 0.5) \text{ mm}$, electron wave-length $\lambda = (4.35 \pm 0.03) \times 10^{-9} \text{ mm}$. Diffraction fringes are shown in Fig. 1.†

The approximative value of the filament diameter can be estimated from the intensity distribution in the geometrical shadow of the filament. The appropriate procedure is described in detail in [2], therefore we give here only a short explanation. We may

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†) For Fig. 1 see Appendix I (p. 804a).

suppose that the intensity distribution in the geometrical shadow of the filament corresponds to interference phenomena produced by two coherent sources situated in the place of the filament, their separation being

\[ 2r' = \frac{\lambda b}{2\Delta l} \]

where \( 2\Delta l \) is the separation of neighbouring fringes occurring in the region of the geometrical shadow. The distance \( 2\Delta l \) (i.e. the distance of two first minima on both sides from the axis of symmetry of the diffraction pattern) determined from the picture of the diffraction phenomenon (Fig. 1) or from a photometric record (curve (a) in Fig. 3) is \( 2\Delta l = 2.4 \times 10^{-4} \text{ mm} \). Corresponding value \( 2r' = 5.6 \times 10^{-4} \text{ mm} \). In this region the value \( 2r' \) is more than 10\% greater than the filament diameter \( 2r \) (compare Fig. 4 in [2]) and therefore we may expect the actual filament diameter \( 2r \) to be about 0.5 \( \mu \text{m} \). That is why we have calculated the intensity distribution \( I \) for several values of the filament diameter \( 0.45 \mu \text{m} \leq 2r \leq 0.52 \mu \text{m} \).

Fig. 2. Graph of the function \( I/I_0 = f(2r, l) \). \( I/I_0 \) — quantity proportional to the intensity, \( 2r \) — filament diameter, \( l \) — distance from the symmetry axis of the diffraction pattern.