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Eleven Thousand Interference Fringes by 1-MV Field Emission Electron Microscope

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A 1-MV field emission electron microscope, which recorded a highest brightness of 1.8 X 10^{10} A/cm^{2}sr at a total beam emission of 30 μA, has been developed [1] and direct observation of superconducting vortices has been reported [2, 3]. However the performance of the microscope as a 'holography electron microscope' has not yet been confirmed. The study reported here developed a new electron biprism for the microscope and confirmed the total performance of the microscope. The newly developed electron biprism, which was of the electrostatic type[4], was designed so that it was isolated inside a column which was shielded by high-permeability materials against stray magnetic fields [4]. The biprism was installed after pre-evacuation to maintain the vacuum in the column and was driven and rotated in precisely the same way as the specimen holder.

Figure 1(a) shows birds-eye and cross-sectional drawings of the electron biprism holder. Figure 1(b) shows an exterior view of the manufactured biprism. The filament electrode was made of fine quartz fiber and covered with gold by evaporation. The final diameter of the filament was 0.8 μm. An electric potential of 1,000 V can be applied to the filament electrode.

After intensive study of the microscope's optical system, we attempted to produce the maximum number of interference fringes in order to confirm its performance as a holography microscope. The entire width of an interference region with fringes was recorded on one microscope film (Kodak SO-163) by an exposure time of 180 sec with a total emission current of 20 μA.

Figure 2(a) shows the interference region with 7,000 fringes, which were not visible at this magnification. Figure 2(b) shows a part of the fringes in Fig. 2(a) enlarged 100 times and the inset shows an optical diffraction of the fringes. When the number of fringes increased to 11,000 or more, the contrast of the fringes became very faint because of the limits of beam coherency. Optical diffraction, however, was clearly observed even in this case. The maximum number of fringes obtained from diffraction was 11,600. In Fig. 3, fringe numbers n from the recorded films are plotted as open circles versus the length between the biprism and image plane L. The theoretical calculation was drawn by a solid line.

When we estimated the maximum fringe numbers from the parameters of wavelength, beam brightness, exposure time and film sensitivity and its resolution, the value obtained was about 12,000, which is close to our experimental result. The results demonstrated high electron beam coherency and mechanical stability. We conclude that the interference condition for the microscope is appropriate and it performs very well as a ‘holography electron microscope’.

References

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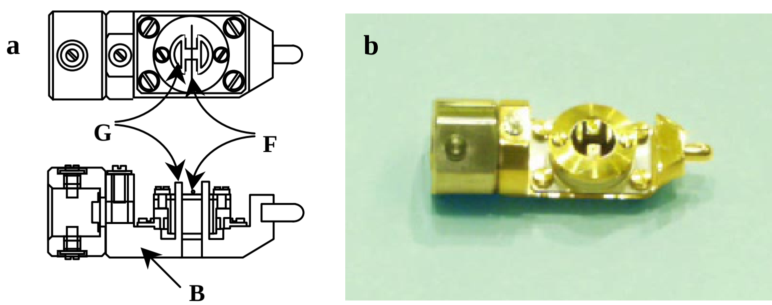

Figure 1 (a) Birds-eye and cross-sectional drawings of the electron biprism, (b) exterior view of the developed biprism holder. Biprism holder B, filament electrode F and grounded electrodes G are indicated.

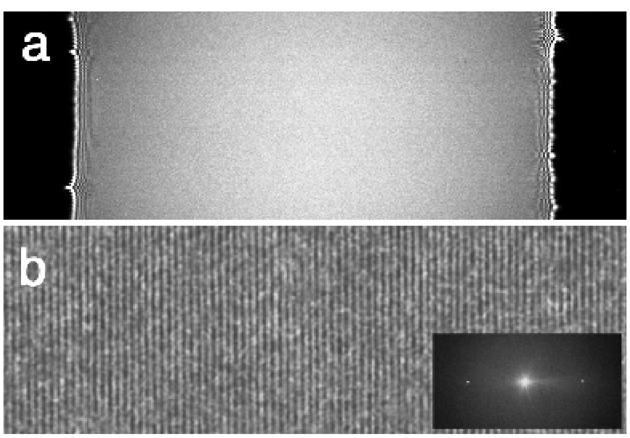

Figure 2 Interference fringes of 7,000 numbers; (a) whole interference region, (b) enlargement of part of interference fringes shown in (a). Inset is an optical diffraction confirmed for straight and parallel fringes.

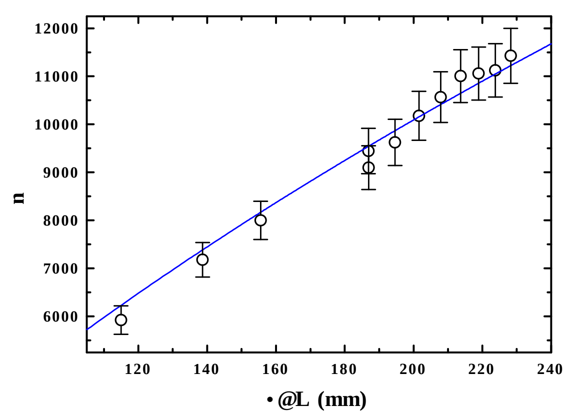

Figure 3 Fringe numbers *n* on the films versus length *L*. Open circles indicate experimental results and the solid line indicates the theoretical calculation.

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