Illumination semi-angle of 10^{-9} rad achieved in a 1.2-MV TEM

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Illumination angle of incident electron beams is one of the important factors in transmission electron microscopy studies. In Lorentz microscopy, it affects the sensitivity in measuring phase shifts due to electromagnetic fields which may exist both inside and outside of a specimen. In electron holography, achievement of small illumination angle is particularly important because it improves interference fringe contrasts in electron hologram [1, 2]. We developed a 1.2-MV transmission electron microscope (TEM) [3] that is equipped with a cold field emission electron gun with superimposed magnetic field [4]. The aim of the present study is to determine the illumination angle of the 1.2-MV TEM.

Illumination angles 2β adjusted by a condenser lens were evaluated from the length L over which the Fresnel fringes can be observed. Figure 1 shows illumination optics. Smaller illumination angles can be achieved by increasing distance d from the beam spot position to the specimen position. The L was obtained by measuring the diameter of circular holes in metallic plate fully filled with Fresnel fringes because this method allows accurate L measurement from micrographs even under the existence of distortions [5]. Figure 2 shows experimentally obtained illumination semi-angles β as a function of d estimated from the condenser lens current. The smallest illumination semi-angle of 4.0×10^{-9} rad was obtained at d=364 mm. In addition, electron gun brightness was estimated to be approximately 3×10^{14} A/m^{2}sr from the obtained illumination semi-angle values and current densities at specimen position determined by using a Faraday cup.

The smallest value of illumination semi-angle of 4.0×10^{-9} rad achieved the 1.2-MV TEM should be highly advantageous for phase shift measurements. Electron holography and Lorentz microscopy studies using this TEM are thus promising techniques to examine weak electromagnetic fields observed in advanced materials.

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6. The development of the 1.2-MV TEM was supported by a grant from the Japan Society for the Promotion of Science through the "FIRST Program" initiated by the Council for Science, Technology, and Innovation.

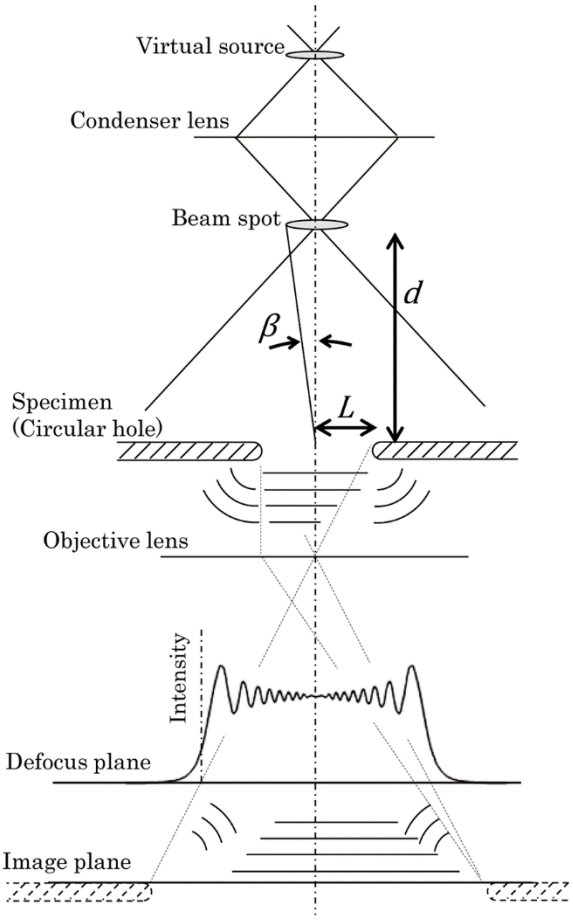

Fig. 1. Illumination optics

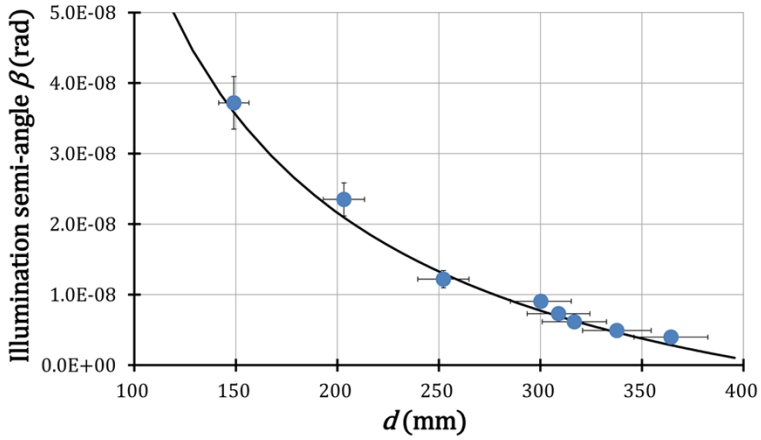

Fig. 2. Illumination semi-angle β as a function of distance d from the beam spot position to the specimen position