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Development of Sample-Scanning Electron Holography

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Off axis electron holography has been a powerful transmission electron microscopy technique to obtain phase information of electrons passed through a sample quantitatively with high resolution. In off axis electron holography, phase information is recorded in an electron hologram that is an interference pattern between an object wave from the sample and a reference wave from vacuum. To extract the phase information from the electron hologram, reconstruction processing must be performed.

The spatial resolution of reconstructed phase images is limited by the fringe spacing of the hologram. The finer fringe spacing gives rise to the lower fringe contrast resulting in the degradation of phase resolution. One of the methods to solve this problem is fringe-scanning (phase-shifting) electron holography, by which phase images are reconstructed from multiple electron holograms with different initial phases [1,2]. The spatial resolution is independent of the fringe spacing and therefore both the spatial and phase resolutions can be high. The difficulty of practical use of it is that fringe must be shifted without the displacement of the sample in each hologram. Furthermore, off-line computer processing with a special reconstruction program is required.

In the present work, sample-scanning electron holography was developed, in which only the sample is scanned one- or two-dimensionally in fixed hologram images using our stage-scanning system [3]. If Gatan STEM Diffraction Imaging system© is available, multiple holograms with different initial phases can be acquired during the one-dimensional sample-scanning instead of the fringe-scanning by combining our stage-scanning system with Digi-ScanII©. The sample-scanning direction should be perpendicular to the fringe. Moreover, only when the intensity of each point on a line perpendicular to the sample-scanning direction (e.g., parallel to the fringe) is counted, two-dimensional phase images are simply obtained without special reconstruction program.

A combination of two-dimensional sample-scanning and signal detection though a pinhole as shown in Fig.1 is more instant and powerful especially for in-situ phase imaging. The intensity of a point in electron hologram is changed by the phase change of an object wave. When we scan the sample and count the intensity of the point at each sample position during the two-dimensional sample-scanning, the resultant intensity map (e.g., scanning image) corresponds to the phase image.

Figure 2 shows a series of electron holograms taken during the sample-scanning, in where the sample is Co nanoparticles on a carbon film. Figure 3(a) shows a phase image obtained from standard electron holography, and Fig. 3(b) shows phase line profiles along a white line in (a) (red) and corresponding positions taken by the one-dimensional sample-scanning electron holography (black). Phase θ is displayed as the cos θ intensity. The intensity difference attributes to an amplitude component overlapped with the cos θ intensity in sample-scanning electron holography.

References
[1] Q.Ru et al., Ultramicrocs. 55 (1994) 209.
[2] K.Yamamoto et al., J.Electron Microsc. 49 (2000) 31.
[3] M. Takeguchi et al., J. Electron Microsc. 58 (2008) 123.

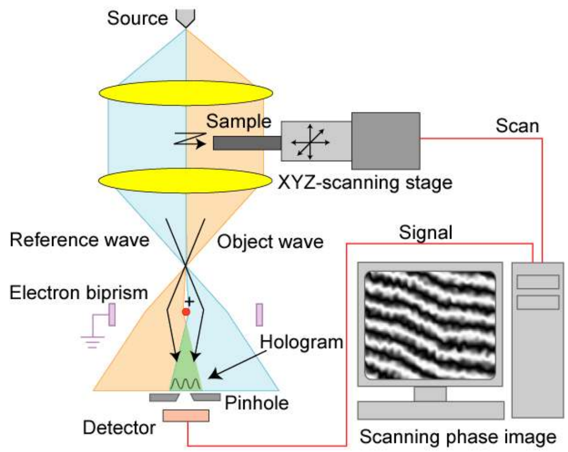

FIG.1 Schematic drawing of sample-scanning electron holography.

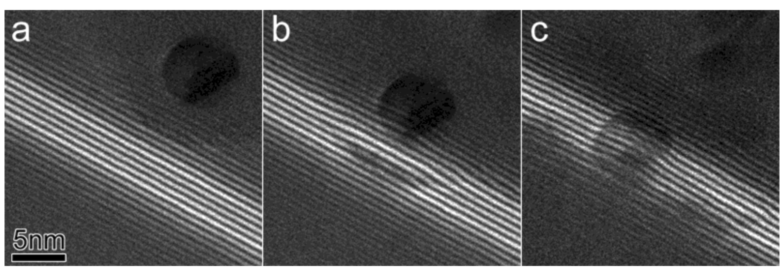

FIG.2 A series of sample-scanning electron holograms.

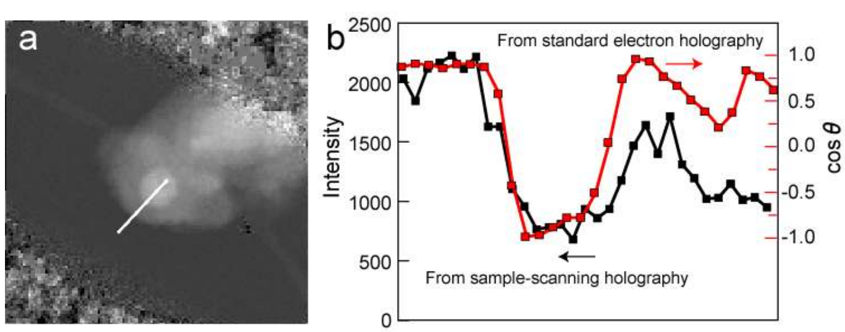

FIG.3 (a) phase image obtained from standard electron holography, (b) phase line profiles of along a white line in (a) (red) and corresponding positions taken by the one-dimensional sample-scanning electron holography (black).

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