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Correcting Phase Imperfections in Electron Holography

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Introduction

Electron holography is an ideal technique and a powerful tool for observing nanoscale electromagnetic fields [1]. Today, most holograms are reconstructed by the Fourier transform method [2,3]. In some cases, a phenomenon in which the contrast reverses abruptly from white to black may occur in phase images directly reconstructed by digital Fourier transform. Two types of such abrupt reversal occur. One is the well-known phase jump of 2π [4] during the digital reconstruction process, caused by the reconstructed phase falling within the range of $[-\pi, \pi]$ [5], and can be unwrapped [6] and smoothly connected using the appropriate software. The other type of reversal is caused by the disconnection of interference fringes due to the weak electron-wave amplitude in specific areas of the specimen. We propose a method for correcting phase imperfections on the reconstructed phase by using image processing in electron holography.

Experimental Procedure

First, the image containing only the interference fringes was reproduced by using a low-pass filter to reduce the influence of Fresnel diffraction and noise [7]. Then, binarization was performed to obtain a binary image of the interference fringes [8]. The singularities disconnected or incorrectly connected are searched out using the skeletonized fringes based on mathematical morphology. Finally, we correct the failed interference fringes, which are mainly disconnected or incorrectly connected, by cut-and-reconnect processing using MATLAB (MathWorks).

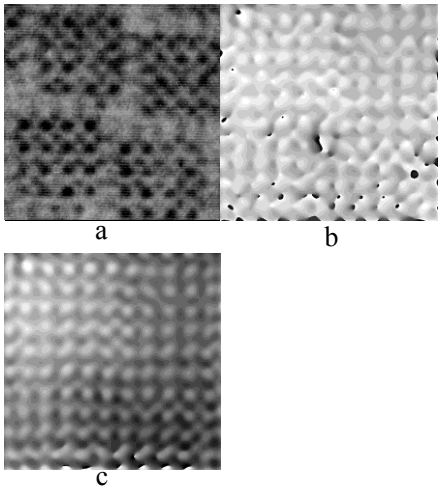

Fig.1. a. original electron hologram;
b. directly reconstructed phase image;
c. Final reconstructed phase image.

Results and Discussion

An electron hologram of the $W_8Nb_{18}O_{69}$ particle captured by a CCD camera is shown in Fig. 1(a). The reconstructed phase image obtained directly from the electron hologram is shown in Fig. 1(b), including some phase imperfections. The reconstructed phase image in Fig. 2(c) obtained from the corrected interference fringes shows that the phase error due to the weak electron-wave amplitude has been drastically reduced.

References

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