Wide-Field and High-Resolution Low-Voltage Scanning Electron Microscopy with Correction of Beam-Image-Shift-Induced Deflection Chromatic Aberration

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We report on a deflection-chromatic-aberration-free beam-image-shifting technique for low-voltage scanning electron microscopy (LVSEM). An LVSEM is useful for low-damage and nanoscale analysis of beam-sensitive materials such as photoresists, organic samples, and two-dimensional materials, but high-speed multi-point imaging capability is also desired for large-area analysis of these samples.[1] One way to achieve high-speed multi-point imaging with an LVSEM is to use the beam-image shift, which shifts the image acquisition areas by deflecting an electron beam. The use of beam-image shift allows us to save time required to shift the image acquisition area by eliminating time-consuming stage movement and relaxation. [2] However, the beam-image shift induces the deflection chromatic aberration, especially when the accelerating voltage is 1 kV or less. As a result, the spatial resolution of the beam image-shifted images deteriorates.

Here, we developed an LVSEM system that uses a Wien filter to correct the deflection chromatic aberration induced by the beam-image shift (Figure 1). The Wien filter generates the deflection chromatic aberration to cancel out the that caused by the beam-image shift. With the developed system, we demonstrated that the deflection chromatic aberration was corrected over 28 μm × 28 μm of the field of view (FOV) covered by the beam-image shift (Figure 2). As a result, the maximum degradation and the variation within the FOV were improved by approximately 1/2 and 1/3 times, respectively. We also confirmed that the response time of the Wien filter was shorter than that of the beam-image shift for the same amount of the aberration. Thus, the correction required no additional settling time. Details of these experiments and applications to pattern measurement will be given in the presentation.

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[1] K. Nakamae, "Electron microscopy in semiconductor inspection," Measurement Science and Technology **32**, 5 (2021)

[2] J. Bouvette *et al*., "Beam image-shift accelerated data acquisition for near-atomic resolution single-particle cryo-electron tomography," Nat. Commun. **12**, 1 (2021)

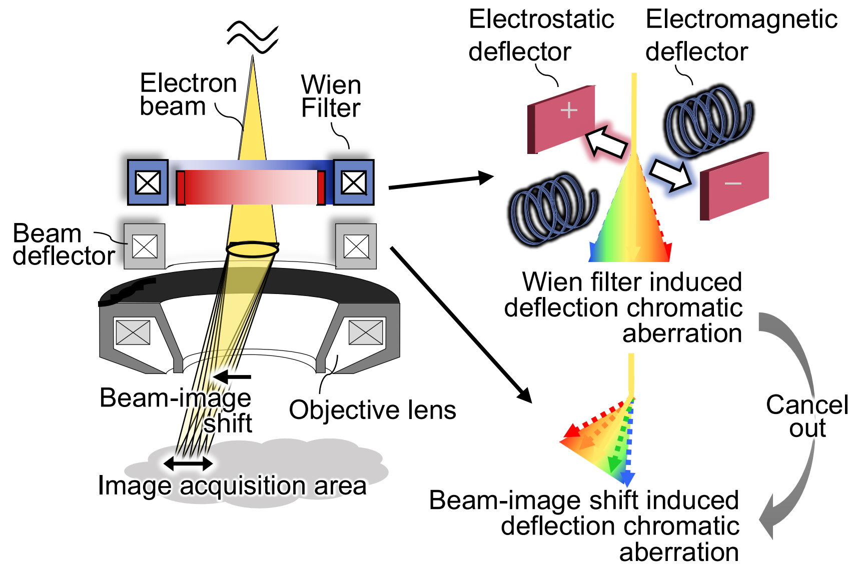

Figure 1. Schematic diagram of the developed LVSEM system that uses a Wien filter to correct the deflection chromatic aberration induced by the beam-image shift.

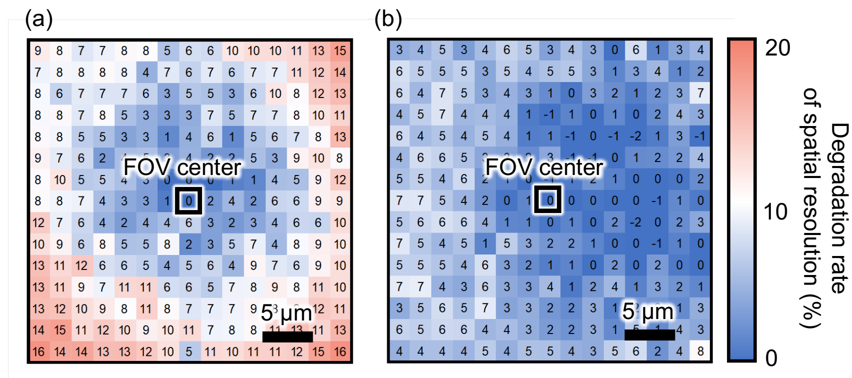

Figure 2. Distribution of the degradation rate of spatial resolution in the beam shifted field of view of the SEM image. Without (a) and with (b) deflection chromatic aberration correction.