Aberration Measurement Using Imaging with Electron-Beam Landing-Angle Sweeping

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It is well known that beam or sample misalignment can cause unexpected aberrations, which degrade image quality during SEM observation. To maintain SEM performance, particularly for cutting-edge semiconductor process control [1], rapid monitoring and feedback techniques are desirable. In this study, the authors propose a novel aberration measurement method that combines imaging, based on two-dimensional sweeping of the electron beam landing angle on the sample, and image processing techniques.

The experimental setup is based on a CD-SEM (CG5000, Hitachi High-Technologies Corporation) modified to enable sweeping of the electron beam landing angle (Fig. 1), together with an image acquisition system designed to record the displacement of the primary electron beam on the sample surface induced by aberrations. Figure 2 presents examples of calculated beam landing-angle sweeping (BLAS) images. A multipole aberration corrector is incorporated into the apparatus for aberration adjustment. Image processing techniques are employed to identify corners and track their positions before and after field-of-view (FOV) shifts in BLAS images, respectively (Fig. 3). Aberration coefficients were determined by correlating the FOV shift with the corresponding aberration-induced displacement differences observed for each detected corner. Figure 4 illustrates the extracted ImA_2 aberration coefficient at various excitation currents applied to the aberration corrector. The results demonstrate that the extracted ImA_2 coefficient exhibits a linear response to the excitation current, as anticipated [2]. Moreover, the slope of the curve is in good agreement with the excitation sensitivity of the corrector for the ImA_2 component, thereby validating the proposed method.

REFERENCES

[1] B. Bunday et al, 'CD-SEM metrology for sub-10nm width features', Proc. SPIE vol.9050 90500T(2014).
[2] J. Zach, M. Haider, 'Aberration correction in a low voltage SEM by a multipole corrector', Nucl. Instrum. Methods Phys. Res. A363(1995).

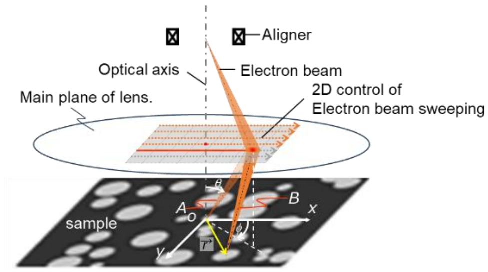

Figure 1. Concept of BLAS imaging for algebraic aberration measurement.
(A) Electron beam trajectory without aberration.
(B) Electron beam trajectory with aberration, showing displacement $\vec{r}$ at the sample surface.

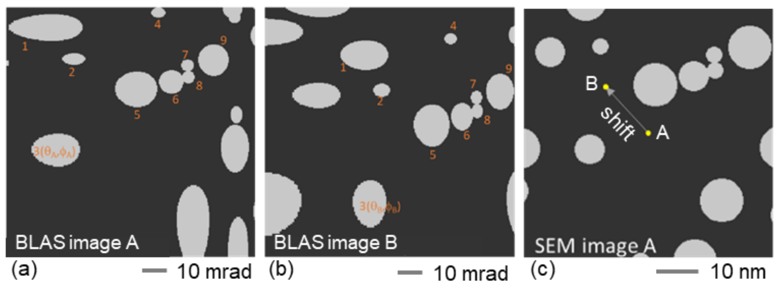

Figure 2. Calculated BLAS image (a) and (b) of a pseudo dot pattern (c) before and after an FOV (Field of View) shift. Residue aberration coefficients (ReA_2, ImA_2, ReB_2, ImB_2) are set to 1.0E-7 m.

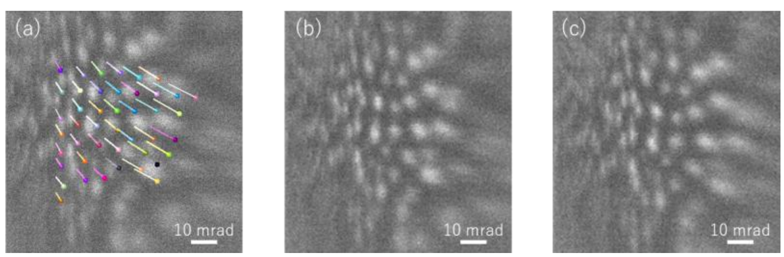

Figure 3. Corner-tracing results (a) between two BLAS images (b) and (c) acquired before and after an FOV shift.

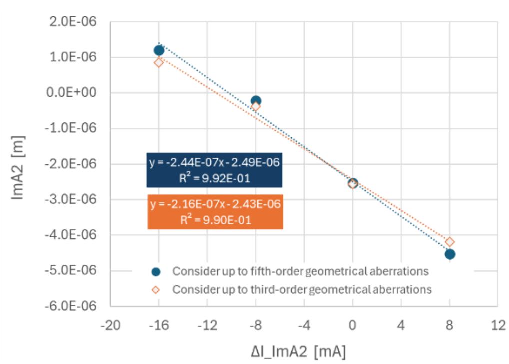

Figure 4. Measured ImA_2 coefficient as a function of excitation current applied to the aberration corrector.