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IT-8-P-1428 Analysis of image distortion on projection electron microscope image

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We have been developing a high throughput projection electron microscope (PEM) for EUV (Extreme ultraviolet) patterned mask inspection system. The PEM provides a sample target with areal illumination at a throughput higher than that obtained from a conventional SEM as shown in Fig. 1. However, image distortion is one of the main issues to be fixed. In order to understand the mechanism behind this issue, simulated PEM images through the imaging electron optics (EO) were analyzed using an upgraded advanced Monte Carlo software CHARIOT. Fig. 2 shows a schematic illustration of a target sample using this approach. Near the pattern with 100 nm half-pitch lines and spaces (L/S), a metal contact with an applied 10 V was added to the substrate. This metal mimics a positively charged area. When a simulated L/S pattern image was obtained by an image sensor placed 30 nm above the target sample, the electrons forming this image could not pass through the imaging optics and remained unaffected by the local charge. On the other hand, when secondary electrons could pass through the imaging optics, the image from the detector placed at a focal plane 200 mm away from the target sample resulted in a distorted image as shown in Fig. 3. These results clearly show that image distortion can be reproduced not by the near-field image but by the focal plane image because the virtual source image is projected on the focal plane in PEM. In the case of focal plane, the L/S patterns bent away from the positively charged area in spite of the fact that secondary electrons should be attracted by the charged area. This phenomenon can be explained using Fig 4. If the SE was bent by the charged area, the virtual source, which SE generates, shifts away from the positively charged area. When the SE bends more, the source shifts farther. As a result, focused L/S patterns are bent away from the positively charged area.These simulation results of image formation including electron scattering and long-range effects of the charging help to understand the mechanism of image distortion and to overcome this issue. At higher energies of SE, the effects of bending become smaller. The energy of SE can be controlled by the extraction voltage. In a novel concept of PEM under development, we applied an extracting electrical field eight times stronger than in conventional PEMs in order to considerably reduce the charging distortion. This reduction effect of image distortion was confirmed by this simulator using the EO data of the novel PEM.

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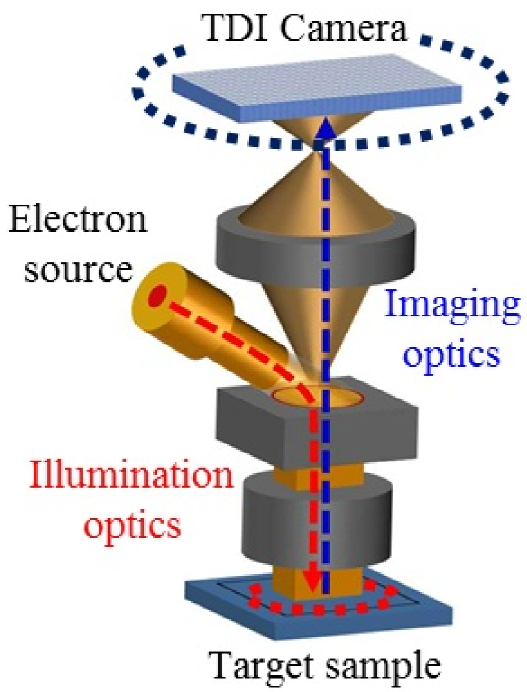

Fig. 1: Schematic illustration of PEM

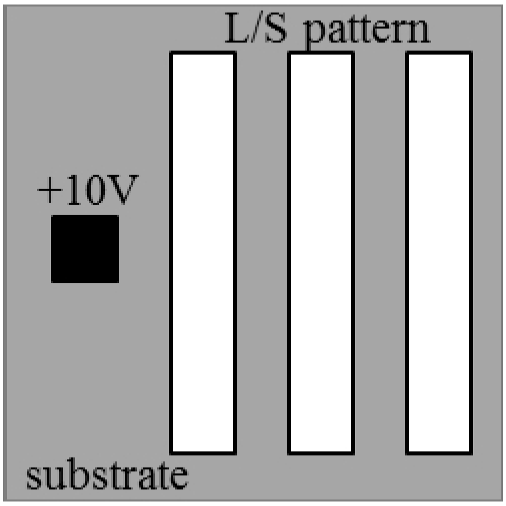

Fig. 2: Schematic illustration of the test sample

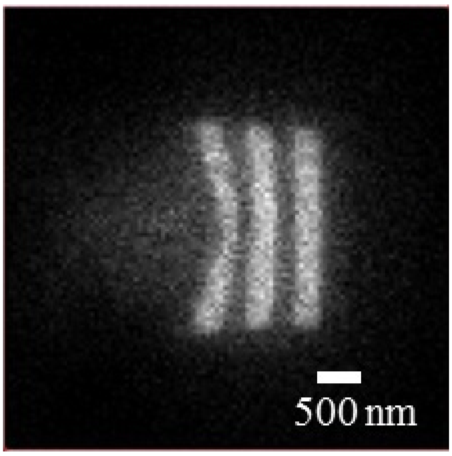

Fig. 3: Simulated image from a detector placed behind the electron optical system

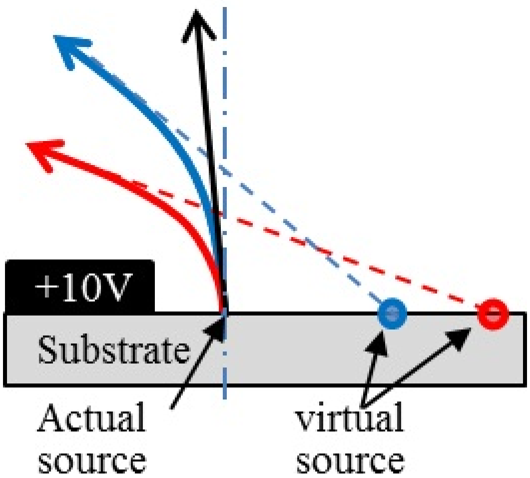

Fig. 4: Schematic illustration of distortion due to local charging