Quantitative Evaluation of Patterning Resolution Capability Using Partially Resolved Regions.

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Amid changing semiconductor landscape, along with the miniaturization of semiconductors progresses, the technology nodes have entered the angstrom era where the high-NA EUV lithography is expected to see growing demand. We have released the MBM™-4000 series for the A14 technology node, which achieves high productivity with excellent writing accuracy. [1] Multi-beam writers need to be continuously developed to meet the requirements of pattern resolution, pattern fidelity, image placement and others. As the patterning resolution is one of the most essential parts, even slight improvements in the resolution have recently become important to determine the development direction of not only resist material but also mask writer. In the conventional evaluation criteria, Isolated Space (IS) minimum resolution was evaluated whether the pattern penetrated into the bottom across the entire CD-SEM top-view image. For example, Table 1 shows IS resolution of two different Positive Chemically Amplified Resist (PCAR) samples. Although values of their minimum resolution turn out to be 18 nm, it is clear that the resolution of the sample B is better than that of the sample A according to the results of patterns from 17 nm to 10 nm. This implies that the conventional method is insufficient to show slight improvements. Therefore, we focused on the pattern partially resolved regions to determine a new method for quantification. We carried out an experiment using the information on the brightness of the pattern edges in the CD-SEM top-view image. Firstly, the CD-SEM top-view image was divided vertically into 64 sections and then the brightness of the edges in each section was calculated and normalized to a value from zero to one. Finally, the values of 64 sections were averaged and treated as a resolution score. The number of obtained SEM images and the number of sections were optimized. Fig. 1 shows score and comparison results of the latent images using the CD-SEM top-view image of samples A and B in Table 1. The score of the pattern penetrated into the bottom across the entire CD-SEM top-view image became one. On the other hand, the score of the pattern partially resolved regions became lower than one. Furthermore, the score decreased as the resolved regions decreased, showing a trend until the pattern disappears completely. The conventional evaluation obtains same results from the two samples, while the resolution score shows that the resolution of sample B is superior to that of sample A. In addition, these results suggest that the resolution score makes it possible to quantitatively compare finer resolution levels. We believe that using this method will be able to quantitatively demonstrate even slight improvements in the resolution of multi-beam mask writers.

Reference

[1] Kenichi, Y., Jumpei, Y., Haruyuki, N., Hiroshi, M., Tomoo, M., Hayato, K., Yoshinori, K., ”MBM-4000 multibeam mask writer enabling mask fabrication for a new era”
in Proc. SPIE 13687, Photomask Technology 2025, (2025).

Table 1 CD-SEM top-view image of Samples A and B

	10nm	11nm	12nm	13nm	14nm	15nm	16nm	17nm	18nm	19nm
Sample A										
Sample B										

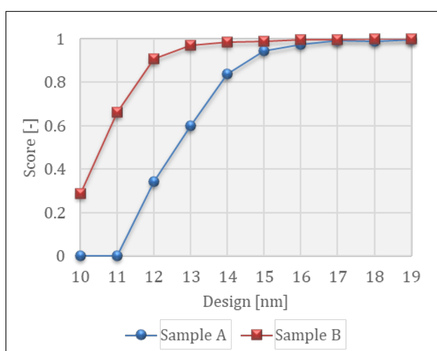

Fig. 1 The results of resolution score of samples A and B

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