Near-neighbor averaging technique: a method for controlling size uniformity in multigenerational masks

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Mask/template-based printing techniques, such as ion beam proximity lithography, x-ray lithography, imprint lithography, etc., are well suited for fabricating large areas of *periodic* nanostructures that have applications in fabricating infrared filters, solid liquid separation filters, pattern media, nanoparticles, optical devices, etc. One of the challenges in implementing these techniques is the fabrication of the large area masks or templates, which are generally patterned by low-throughput electron beam lithography. One approach to reducing the cost of the mask for periodic structures is to print, by step and repeat, large area second-generation masks using a small area, lower-cost master mask. However, it is generally a challenge to control the quality of the pattern over many mask generations.

Our approach to improving pattern uniformity and, consequently, mask cost, is to average the periodic mask pattern. In the approach, termed near-neighbor averaging, the mask images are printed multiple times over the neighboring features, with a displacement equal to the pattern pitch and an exposure dose that is scaled from the critical dose. By using this technique, missing features are filled in by the average of their neighbors (although they are slightly underexposed), undersized features are enlarged, and oversize features print closer to the mean. As the number of offset exposures is increased, the uniformity improves. The technique was experimentally validated and also modeled to using a Matlab routine. Figure 1 shows the (a) measured and (b) simulated size variations of a stencil mask whose image was averaged over N adjacent neighbors. Figure 2 shows the images of a mask with a very large size variation printed in PMMA with (a) a single exposure and (b) four offset exposures. Although not perfect, the uniformity in the second image has improved significantly and should improve further in subsequent mask generations. It should be noted that this technique is applicable for micro-scale variations in size, not for macro-scale variations. This work is supported by National Science Foundation grants ECCS-0404308, ECCS-0702752, and Texas Advanced Research Grant 003652-0016-2007.

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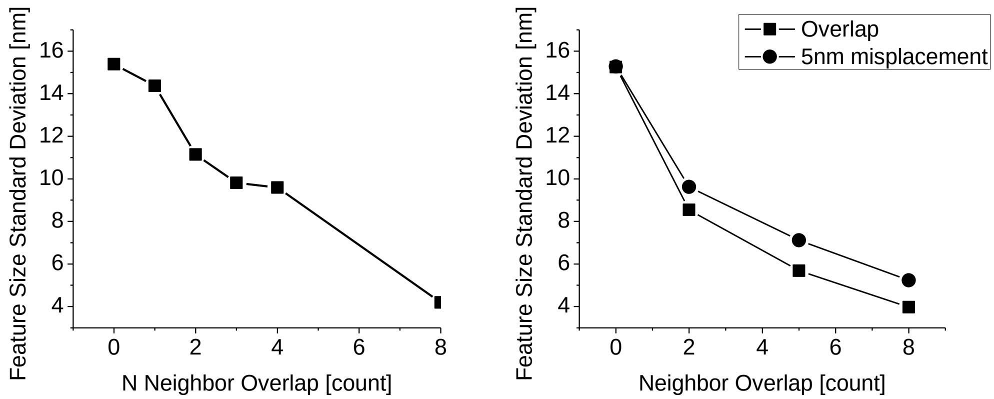

Figure 1. (a) Measured feature size standard deviation, sigma, versus number of overlapping neighbors, N, used during exposure. (b) Simulated behavior for features of similar size and size distribution.

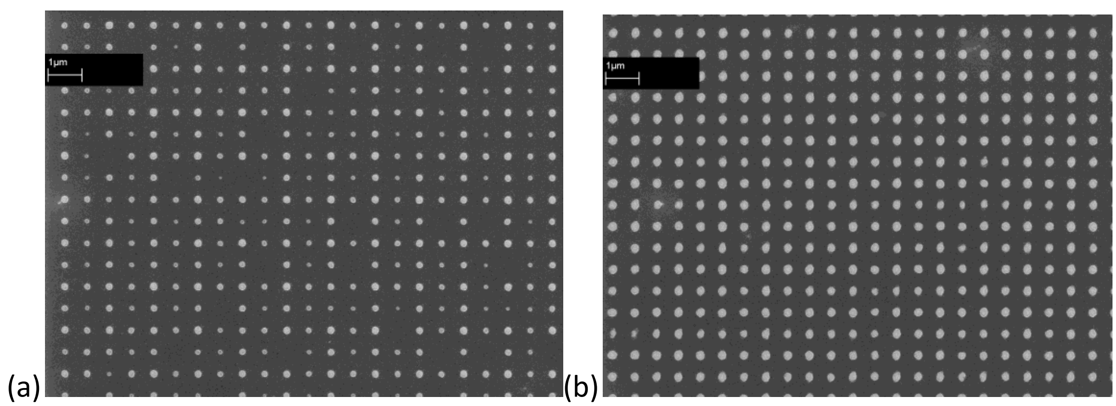

Figure 2. SEM micrographs of similar areas in a PMMA exposure (a) without neighbor averaging, and (b) with N=4 neighbor averaging.