EUV Holographic Lithography: An Image Formation and Optimization Study

A. Isoyan[a], Y.-C. Cheng[a], F. Jiang[a], Srinivas B. Bollepalli[b] and Franco Cerrina[a]
[a]*Center for Nanotechnology, University of Wisconsin-Madison, USA*
[b]*Intel Corp., Portland, Oregon*

Extreme Ultraviolet Lithography (EUVL) is one of the promising candidates for the next generation lithography approach toward the sub-32nm lithography. EUV interference lithography is commonly used for creating periodic patterns using multi-layer coated reflective optics or transmission diffractive gratings[1], providing a good way to achieve or approach the ultimate resolution. A natural extension of EUV-IL can be EUV *Holographic* Lithography (EUV-HL), where a *computer generated hologram* (CGH) can be used to form any desired image. This approach has the great advantage of not relying on complex optical systems to form the image. In previous work[2], we reported the first results from a EUV holographic lithography technique, where CGHs were fabricated as transmission masks on extremely thin SiNH membrane with a Cr absorber layer to reconstruct a target pattern in the resist. A CGH can be visualized as the coherent superposition of a set of zone plates, each corresponding to a single pixel of the input image object. We note that from an imaging point of view, a CGH can be considered as a non-periodic diffraction optic element. The "hologram computation" provides a way around a complex optimization process. Indeed, we have computed the image of two typical target patterns (Fig. 1, 22nm CD and focal distance of 1 mm) using CGHs (Fig. 2) and another imaging optimization algorithm that essentially creates an extreme case of RET for a binary EUV transmission mask (Fig. 3). Both approaches yield similar results, and we will compare the outcome in detail. It is important to note that the CGH is a grayscale image, so that for lithographic fabrication it must be converted into a binary pattern; the quality of the final image is strongly affected by the conversion method[3]. We found that using a half-tone representation of the gray scale yields the best results.

In this study, we will discuss in detail the questions related to the development of an accurate EUV-HL image formation system. The optimization of CGH structure will be performed in order to improve the image quality by several algorithms similar to optical proximity correction, in particular using half-tone images for the CGH as well as pattern modification (RET). We will discuss the design of optimized binary CGHs for imaging of complex patterns down to 22 nm resolution, and beyond. The results will be compared to experimental data.

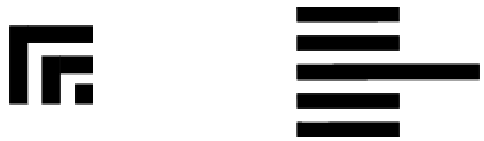

Fig. 1. Standard resolution test patterns.

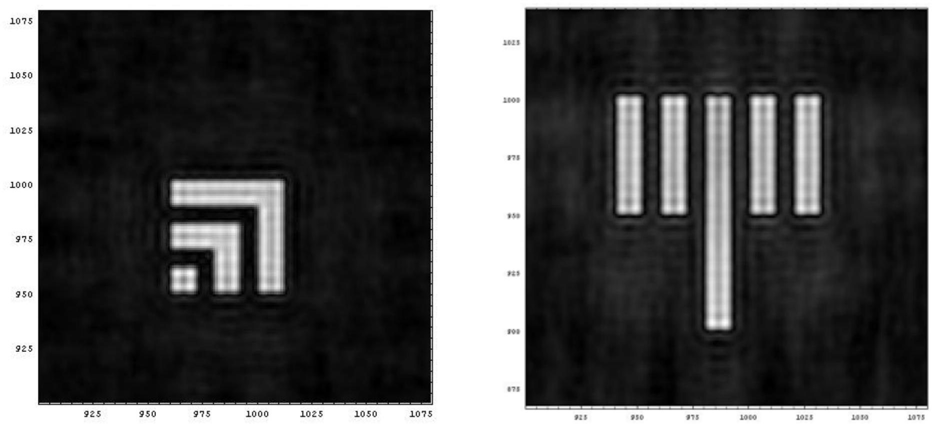

Fig. 2. Reconstructed image of test patterns (CD = 22nm) using half-tone optimization algorithm;

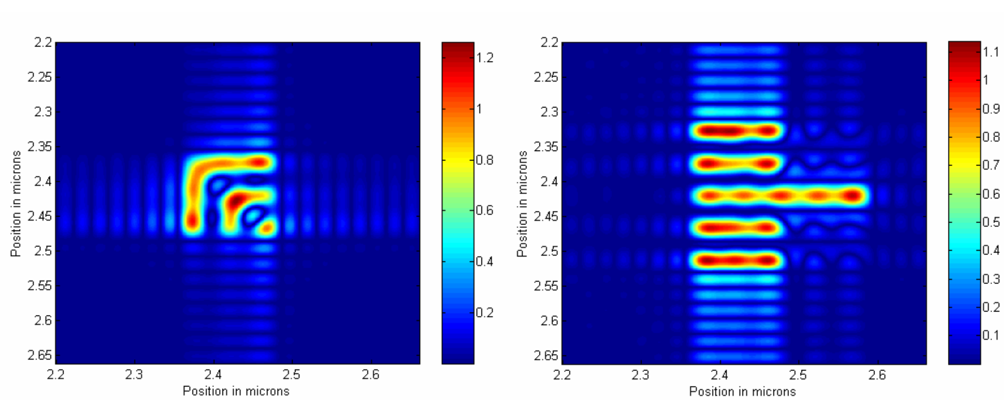

Fig. 3. Reconstructed image of test patterns (CD = 22nm) using optimization algorithm.

References:

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3. Uriel Levy, Yoav Shrot, Emanuel Marom, and David Mendlovic, APPLIED OPTICS, Vol. **40**, No. 32 (2001).