Optical proximity correction using diffraction holography technique

Artak Isoyan, Lawrence S. Melvin III
Synopsys, Inc. 2025 NW Cornelius Pass Road, Hillsboro, OR 97124, United States
e-mail: isoyan@synopsys.com

In optical lithography process modeling, the challenge is to create an optical proximity correction (OPC) that projects the input design polygons onto a wafer image. As microelectronic feature sizes continuously become smaller, lithographic processes are being pushed to their theoretical limits requiring more complex OPC techniques. The OPC correction itself is an iterative process, and requires significant computational resources to calculate the sizes and positions of modified pattern features. Further increasing computational complexity, sub-resolution features are also added to increase pattern printability. The major goal of OPC is to keep the geometry printed on the substrate as close to the target pattern as possible. A challenge in OPC is to reduce number of iterations correction process to reduce throughput time while maintaining this correction fidelity.

Traditional compact OPC models consist of two parts; the optical image formation and photoresist effects compensation. The aerial image calculations are based on the underlying bandwidth limited optical system model, which filters out most of the high order diffracted effects resulting in the severe loss of higher frequency components in the projected mask image. This filtered aerial image (which is a distorted/blurred image due to missing high frequency components) combined with a photoresist response results in a wafer pattern which has poor fidelity due to insufficient information to fully reconstruct the target pattern.

In this work, a new methodology for OPC mask correction is proposed based on diffraction holography principles. A similarity between traditional OPC corrected patterns and synthesized holographic pictures or Fresnel zone plate fringes is readily observed[1,2,3]. The proposed method consists of two steps. First, an in-line hologram (Gabor hologram) is generated by computing the diffraction pattern of the target pattern (the interference of a coherent reference wave front with the wave fronts diffracted or scattered by a target pattern). Second, the computed hologram is synthesized to form a mask for a conventional optical system. The hologram is generated at a location which corresponds to the optical path length (from mask down to wafer) of the optical system. In the reverse imaging process when the coherent wave front interferes with the hologram, the reconstruction of the object is formed at the imaging plane of the hologram, i.e. where the originally the object was located. In principle, the aerial image can be considered as first

---

[1] Y. Granik, "Fast pixel-based mask optimization for inverse lithography", J. Micro/Nanolith. MEMS MOEMS. 5(4), 043002, 2006.

[2] L. Rogers, "Gabor diffraction microscopy – the hologram as a generalized zone plate", Nature 166, 236-237 (1950).

[3] Y. C. Cheng, A. Isoyan, J. Wallace, M. Khan, and F. Cerrina, "Extreme ultraviolet holographic lithography: Initial results," Appl. Phys. Lett. 90, 023116-023118 (2007)

order approximation resist model, and hence the wafer photoresist effects are not included in the mask synthesis process for this discussion. The proposed process can respond to multiple mask synthesis processes and can output either binary or phase shift masks. As a verification step the generated mask is used in conventional model-based OPC modeling flow to evaluate pattern printability.

Fig 1. Target pattern

Fig 2. Printed wafer image of target pattern using model-based OPC model

Fig 3. Hologram of the target pattern, synthesized as a binary mask

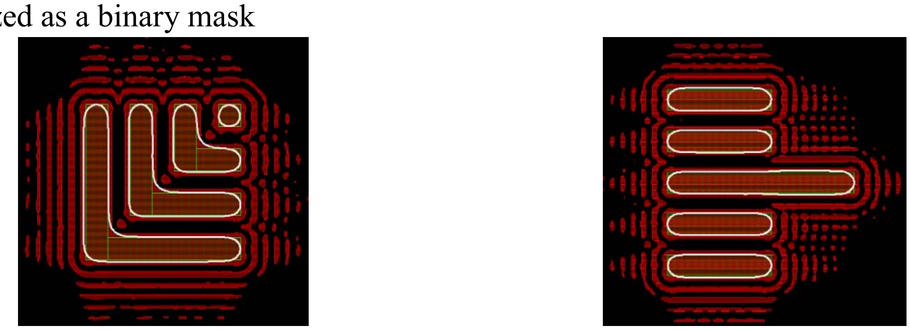

Fig 4. Printed wafer image of synthesized hologram using model-based OPC model