Pattern Specific Optical Models

Edita Tejnil, Konstantinos Adam, Michael Lam

Mentor Graphics Corporation
1001 Ridder Park Drive
San Jose, California 95131

Computational efficiency of the models used in optical proximity correction (OPC) continues to be a necessity in photolithography applications. The drive to increase feature density and improve process resolution demands ever more complex resolution enhancement techniques, such as double exposure patterning. Increased run times of OPC models are a natural consequence of the increased complexity near the optical resolution limit. Improvements in computational hardware and model efficiency can be used to mitigate the increase in run time resulting from rise in model complexity.

The optical image calculation portion of the OPC model often requires significant increase in computational resources as the model complexity increases. The current approach for fast image calculations utilizes the Hopkins formulation of the imaging equations and the sum-of-coherent systems (SOCS) approximation. The SOCS approximation decomposes the optical system response function into a sum of products of its eigenvalues and eigenfunctions, or kernels, via singular value decomposition. The partially-coherent optical imaging system is then represented as a sum of images formed by coherently illuminated optical systems with transfer functions corresponding to the kernels of the optical system response, weighted by the corresponding eigenvalues. Current OPC models typically use few to tens of summation terms in the image computation. The number of required terms increases with a number of factors, including higher NA, defocus, lower partial coherence, etc. The optical model computation time is proportional to the number of kernels used.

The contribution of each term to the final image depends not only on the optical system, described by its eigenvalues and kernels, but also on the mask pattern. The complex exposures schemes needed for resolution improvement also impose design rule restrictions on the layout. As a result, layout simplification has accompanied resolution enhancement in practice. Hence in most applications, the layout is restricted and not random. This implies that some terms in the SOCS approximation are likely to be negligible in practice. Ignoring such terms can improve computational efficiency. In this paper, several approaches to identify the SOCS terms that can be neglected in an OPC model applied to a given layout are explored. The different approaches are quantified in terms of computational efficiency and model accuracy.

Short Version of Abstract

Computational efficiency of the models used in optical proximity correction (OPC) continues to be necessary in photolithography employing resolution enhancement. Improved hardware and model efficiency can mitigate the increase in run time resulting from rise in modeling complexity. The current approach for fast image calculations in OPC utilizes the Hopkins formulation of the imaging equations and the sum-of-coherent systems (SOCS) approximation. In this paper, several approaches to identify the SOCS terms that can be neglected in an OPC model applied to a given layout are explored. The different approaches are quantified in terms of computational efficiency and model accuracy.