Chemically Amplified Resist Modeling in High Compact Model Format for Photolithography Process Simulation

Thomas Mülders[a], Artak Isoyan[b], Lawrence S. Melvin III [b], Hans-Jürgen Stock[a]
[a] *Synopsys GmbH, Karl-Hammerschmidt-Strasse 34, 85609 Aschheim/Dornach, Germany;*
[b] *Synopsys Inc. 2025 NW Cornelius Pass Road, Hillsboro, OR 97124, United States*

As the feature size becomes smaller, modeling the photoresist development process is necessary to improve the lithography process simulations robustness for optical proximity correction (OPC). Resist modeling is often considered to be less rigorously treated than modeling of the optical step. One reason is that detailed information about the chemical composition of the photoresist is often not available. Furthermore, the relevant processes happening inside the chemically amplified resist (CAR) are mostly not characterized precisely. Thus one is faced with the problem of calibrating model parameters, i.e. fitting the model parameters such that a calibration data set of measured pattern characteristics is accurately reproduced by simulation. However, the OPC model quality is then to be assessed not only by the goodness of fit to the calibration data set but also by the model's ability to predict an independent validation data set.

A serious complication for resist modeling is that accurate physical modeling is computationally expensive. While computational speed is already a tough requirement for a rigorous lithography simulators typically dealing with small chip areas of a few square micron, the speed requirements are even much more stringent for optical proximity correction engines where the resist model is to be applied for the full chip. In recent years, several approaches for physical resist modeling were developed to approximate the photoresist development, such as diffusion, kinetic, dissolution, acid-quencher models, etc., however it is generally difficult to achieve both sufficient levels of accuracy and practical speeds of calculation. Hence it is necessary to model process simulation using specially developed approximation algorithms for low CPU time consumption.

In this study a computationally fast method for simulation of the resist modeling based on the post-exposure bake (PEB) reaction-diffusion processes is compared with rigorous lithography simulator by looking into the model accuracy, the prediction power and the computational runtime. The simplified reaction-diffusion PEB model reduces the computational cost while keeping the accuracy of the model and providing good calibration results (RMS of CD deviations). Furthermore, several conventional approximation algorithms for CAR resist modeling along with a simplified reaction-diffusion PEB model have exercised on several empirical and virtual data sets for model CD prediction of measured verification patterns, as well as model contour/SEM image overlays for the model quality.