Process Window Modeling using Focus Balancing Technique

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In lithography process modeling the challenge is to create an optical proximity correction (OPC) model that transforms the input design polygons onto a wafer image. The OPC models are based on complex mathematical calculations of actual physical processes of optical lithography and resist exposure, and as well as on statistical methods. The complexity of OPC models and the number of model components (parameters) are drastically increasing as the integrated circuits continue to shrink device. Hence there is a need for an improved methodology to increase lithography process simulation robustness and to fully capture the optical lithography and resist chemistry processes. Furthermore, the physicality loss of the model reduces quality of the model in terms of fit, prediction, process window interpolation and extrapolation. The *depth of focus* and the *process window* are two important metrics for practical characterization of the usability and quality of the OPC model. Hence, in order to model a high quality OPC model, not only the nominal empirical data should be fitted but the modeling of focus-exposure matrix should be also matched. In most cases in order to build successful process window OPC model, conventional approach is to use empirical data with several process conditions. But this significantly increases the total model calibration time, since the runtime in most cases is a linear function from the number of process conditions.

In this work we present a process window OPC modeling which requires only nominal process condition empirical data as an input. In order to guarantee modeling success, a focus balancing technique is used during model calibration. Optionally, same technique can be applied even if all the process conditions are provided. Since the model calibration is mainly based on nominal process condition empirical data, the quality of the data and as well as the wafer position and the exposure dose are critical. The challenge in focus balancing technique is to ensure that the provided empirical data is at its best nominal dose/defocus position and if not how much it is shifted. The model optimization method is based on a stepwise fitting methodology where staged optimization of the OPC model components is used. Components are added into an OPC model in the order of more physical to less physical, starting from mask and optics. In each optimization stage a component is optimized using global regression methods and then the optimized parameters are locked and not regressed during further model optimization. This method has been tested and compared with conventional optimization methods. Model CD prediction of measured verification patterns, as well as model contour/SEM image overlays were used to assess the model quality.