A New Parametric Proximity Effect Model Calibration Method for Improving Accuracy of Post-lithography Patterning Prediction in Sub-32-nm Half-Pitch Low-Voltage Electron Beam Direct-Write Lithography

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Accelerating voltage as low as 5 kV is being considered for high-throughput electron beam direct-write lithography for the 32-nm half-pitch node and beyond. Accurate proximity effect modeling is essential to pattering prediction. It requires thorough understanding of electron scattering in resist, accurate simulation of energy intensity distribution, and effective data fitting algorithm to generate parametric models used in most proximity correction software. Although electron scattering has been intensively studied, it is found that conventional model calibration method needs significant improvement. A new method adopting a direct search fitting algorithm with a novel merit function has been proposed. It is numerically more robust than gradient-based method, less sensitive to choice initial parameters, and more accurate (Fig. 1). Preliminary experimental results indicate that a new combination of a single Gaussian plus double exponential functions can well represent low-voltage electron scattering (Fig. 2). The impact of curve-fitting algorithms to patterning prediction accuracy is characterized by simulating one-dimensional grating layouts with various pitches and a representative two-dimensional six-transistor-SRAM layout. (Fig. 3) The proposed method out performs the conventional in various cases.

[1] S.-M. Chang et al., Proc. of SPIE **6921**, 69211R-1 (2008)

[2] C.-H. Liu et al., Proc. of SPIE **7140**, 71401I (2008).

[3] S. Manakli et al., J. Micro/Nanolith. MEMS MOEMS **6**(3), 033001 (2007).

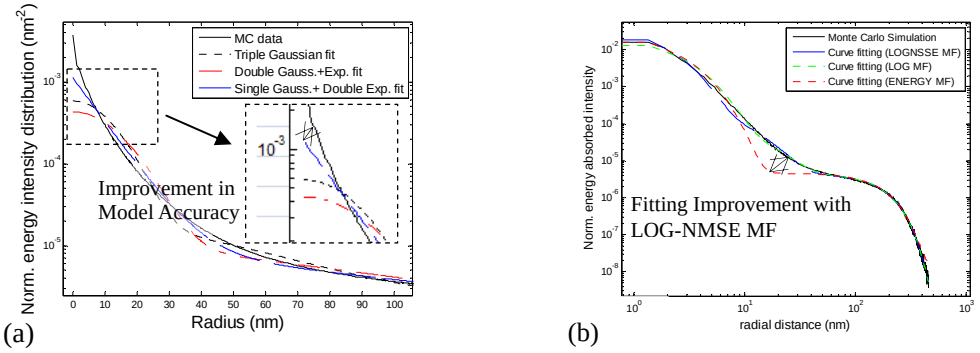

Fig. 1 Comparison of (a) different models and (b) merit functions in 40nm ZEP with 5 keV electron beam.

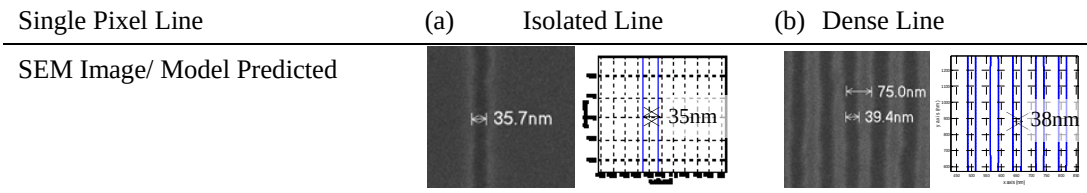

Fig. 2 SEM images and model-predicted pattern shapes for (a) isolated line and (b) dense line.

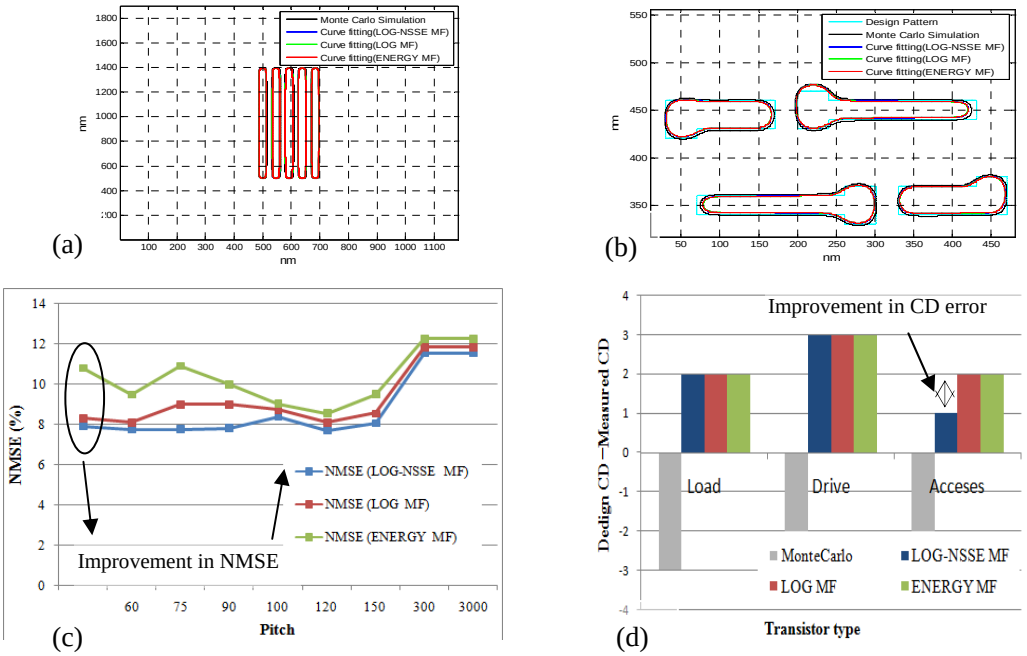

Fig. 3 Comparison of different merit functions on (a) 1D grating layouts with various pitches, (b) 2D

6T-SRAM layout, and the impact: (c) normalized mean square error, NMSE (d) CD error.