Pattern matching, simulation and metrology of complex layouts fabricated by electron beam lithography

N. Tsikrikas, D. Drygiannakis, G. P. Patsis, I. Raptis
Institute of Microelectronics, NCSR "Demokritos", Athens, 15310, Greece
S. Stavroulakis, E. Voyiatzis
Photronics Hellas S.A. 19500, Lavrio, Attika, Greece

The increase in pattern complexity due to the optical lithography correction, the tight requirements of critical dimension (CD) control and the defect inspection difficulties result in increasing IC manufacturing cost.

The goal of this work is the development of a software tool for the prediction of pattern transfer of complex layouts, before the actual pattern transfer on the mask plate. The software consists of four modules aiming in i) layout file management, ii) pattern matching of SEM images with the layout, iii) 2D/3D layout simulation and iv) metrology (Fig. 1).

The first two modules handle the layout files (CIF or GDS) and perform the pattern matching[1] of the SEM images with the layout, by applying a cross-correlation approach (Fig. 2). In addition in the second module the simulation-metrology window based on the SEM image is defined.

In the third module the 2D/3D lithography simulation is carried out. The Energy Deposition Function (EDF) due to e- beam exposure using Monte Carlo techniques is calculated. Convolution of the EDF with the layout, returns the total energy deposition in the resist (Fig. 3(b)) which is used as input for the stochastic[2] lithography simulation. This part uses very detailed microscopic modeling of the resist film, and post exposure (PEB, development) processing steps and delivers the final 2D/3D resist shape (Fig. 3(c)). In the metrology module a comparison of the layout, the SEM image and the simulation results is accomplished. In Fig. 4 the CD and LWR results for the metrology window (Fig. 3a) are presented. In this figure, Simulation 1 corresponds to patterning with chemically amplified resist and Simulation 2 with conventional one, based on the aerial image of Fig. 3b.

The whole process could be useful in the validation of design rules. The effects of exposure, material and processes on the layouts will be presented and particular examples of LWR effects on complex layouts will be investigated.

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1. K. Miura, M. Fujita, K. Nakamae, H. Fujioka J. Vac. Sci. Technol. B23 3065(2005)
2. G.P. Patsis, E. Gogolides J. Vac. Sci. Technol. B23 1371(2005)

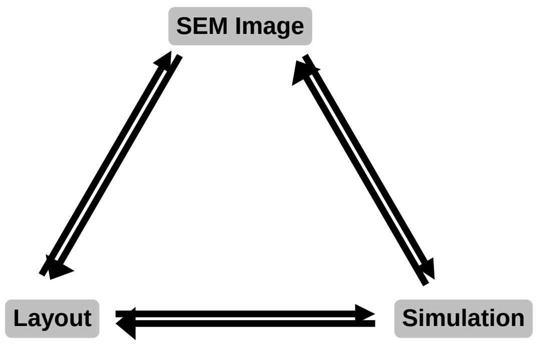

Fig. 1: Schematic representation of the software

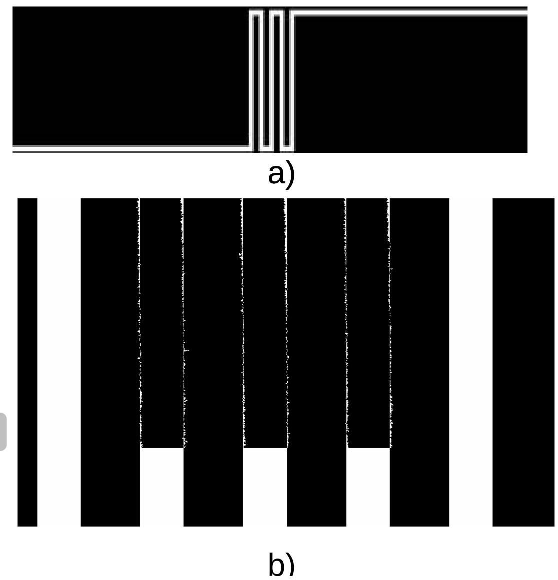

Fig. 2. (a) The whole layout (b)matching SEM image with the layout

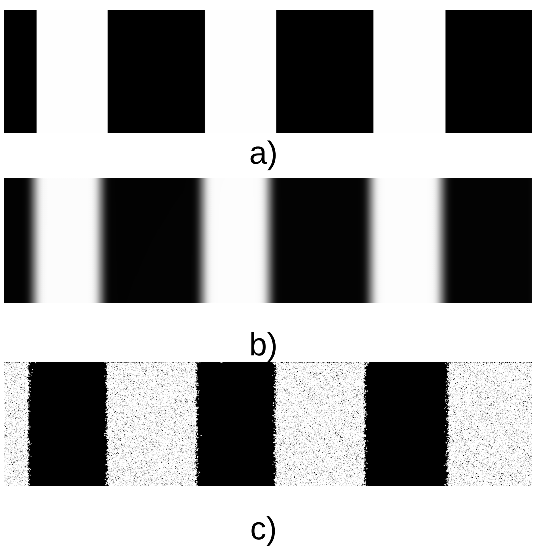

Fig.3. 2D stochastic simulation (a). Part of layout. (b). Simulated energy deposition (c). Resist pattern after development.
Resist: linear polymer chains (30 monomers per chains). Free volume ~6%. PAG loading 30%, deprotection fraction 0.8. Aerial image contrast = 1.

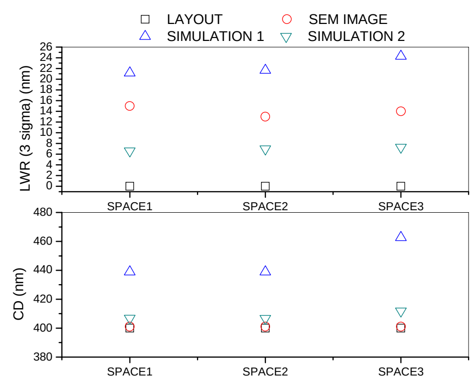

Fig. 4. CD and LWR measurements for the metrology window of Fig. 3. Layout has CD of 400nm. SEM image analysis confirms that the transferred pattern has the same CD and also determines LWR of each patterned space.