Evaluation of Hybrid Lithography and Mix & Match Scenarios for Electron Beam Direct Write Applications

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E-Beam direct writing on silicon wafers for critical layers is currently discussed as an option for early device and technology development as well as for fast prototyping. For logic devices this approach recently has been successfully demonstrated by integration of variable shaped beam (VSB) E-Beam direct writing into semiconductor device manufacturing [1].
E-Beam Lithography usually is limited by high writing times when complete layers are supposed to be printed on a wafer. A detailed writing time analysis for different DRAM technology nodes can be found in [2]. The long writing time restricts the exposure of the whole wafer with E-Beam for modern technologies. On the other hand, full patterning of single layers is required due to processing constraints, like etch loading and CMP quality issues. Therefore the implementation of complex integration solutions is necessary in order to face this issue, such as Mix & Match processes (application of two consecutive litho types for one layer) or Hybrid Litho (double exposure of a single resist with two different exposure steps) [3].
For that, commercially available resist samples from various suppliers have been exposed at Qimonda's DRAM pilot line environment using both, E-Beam and optical exposure, and vice versa. For classical optical exposure, DUV (248nm) and ArF (193nm) litho was applied using E-Beam positive and negative chemically amplified resists.
Due to the diverse, sometimes contradictory requirements and properties of the different material platforms (e.g. resolution, sensitivity, vacuum stability, etch resistance, etc.), a unique material for true hybrid litho is difficult to find. For example, the tested ArF resists are very limited applicable for E-Beam exposures due to their low vacuum stability. Optimized resist components (e.g. loading and type of PAGs) are necessary for future E-Beam/ArF Hybrid Lithography.
We will give an overview about process window evaluation and characteristic features of several resist materials for E-Beam / optical Mix & Match applications and implementation into new integration concepts.

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[3] L. Pain, C. Higgins, C. Gourgon et al., J. Vac. Sci. Technol. B **18** (6), 3388-3395 (2000).

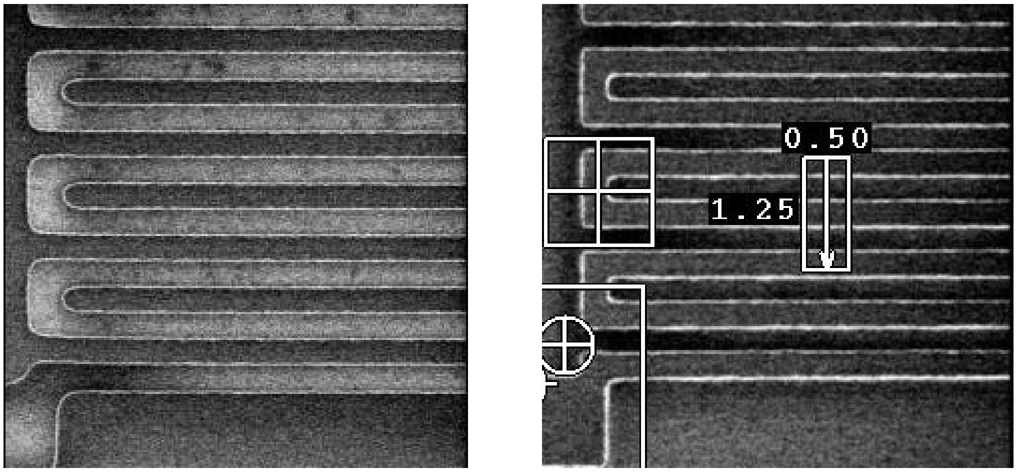

Fig. 1: CD-SEMs of 330nm dense L/S pattern in E-Beam negative chemically amplified resist (resist thickness: 840nm) printed with DUV lithography (left) and E-Beam lithography (right, inverse pattern).

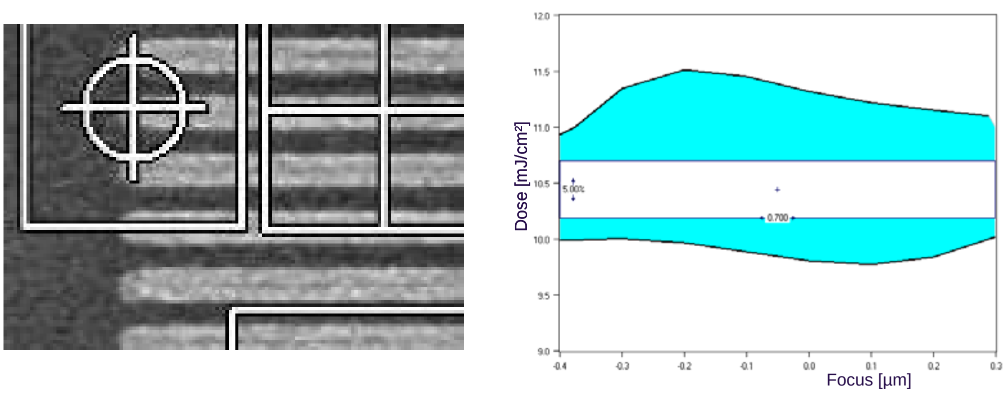

Fig. 2: Process window evaluation for DUV optical exposure of the same E-Beam n-CAR resist with reduced film thickness (127nm). Feature size: 180nm dense L/S.