Mask Aligner Process Simulation for Advanced Lithography and Resolution Enhancement Techniques

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Mask aligner lithography is the most cost effective lithography technique for micro manufacturing for structures down to approximately 3µm in size. While mask aligners were pushed out of front-end lithography many years ago due to the resolution limits, the constant improvement of mask aligners have always opened new applications and markets for cost effective optical lithography. For example, the recently introduced novel illumination system for mask aligners[1] allows the use of common resolution enhancement techniques (RET) for mask aligner lithography like OPC (optical proximity correction) and SMO (source mask optimization). Here the customized illumination like, e.g., ring-illumination, quadrupole, multipole, Maltese cross, etc. is the key function. However, the option for a free choice of illumination settings increases the number of process parameters drastically. So it's obvious that prior process simulation is meaningful for the process development.

Process simulation helps to avoid or utilize diffraction to improve resolution and lithographic quality. This is well known in projection lithography for front-end semiconductor manufacturing. A huge process parameter space can be tested and refined using computers rather than running through lengthy and expensive series of test exposures.

This paper will demonstrate the potential of mask aligner lithography simulation for development of RET. The verification of simulated OPC structures with experimental data validates the process simulation algorithm as well as demonstrates that OPC is possible on mask aligners. The comparison for an alignment cross with and without OPC features is shown in figure 1. The improvement of the pattern fidelity is clearly seen in simulation and experiment. Even more possibilities exist with the use of an aperture phase shift mask (Figure 2), were also the resolution can be enhanced.

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[1] M. Hornung, U. Vogler, and R. Voelkel, J. Vac. Sci. Tech. B 28 (2010), C6Q6-C6Q11.

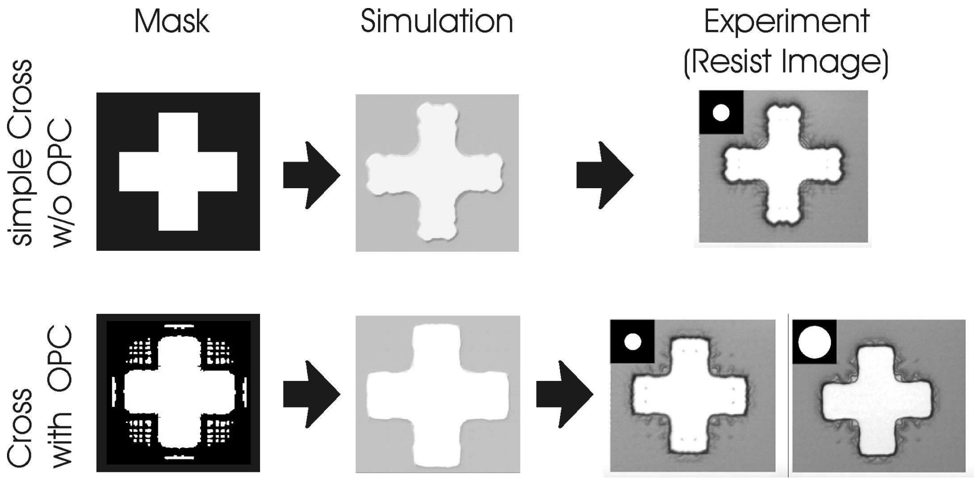

Figure 1: Comparison of a 10 µm alignment cross printed in 30 µm exposure gap w/o (top) and with (bottom) OPC structures. Both, simulation and experiment, shows the better pattern fidelity for the structure with OPC. Here the resist images for two different illumination settings are shown.

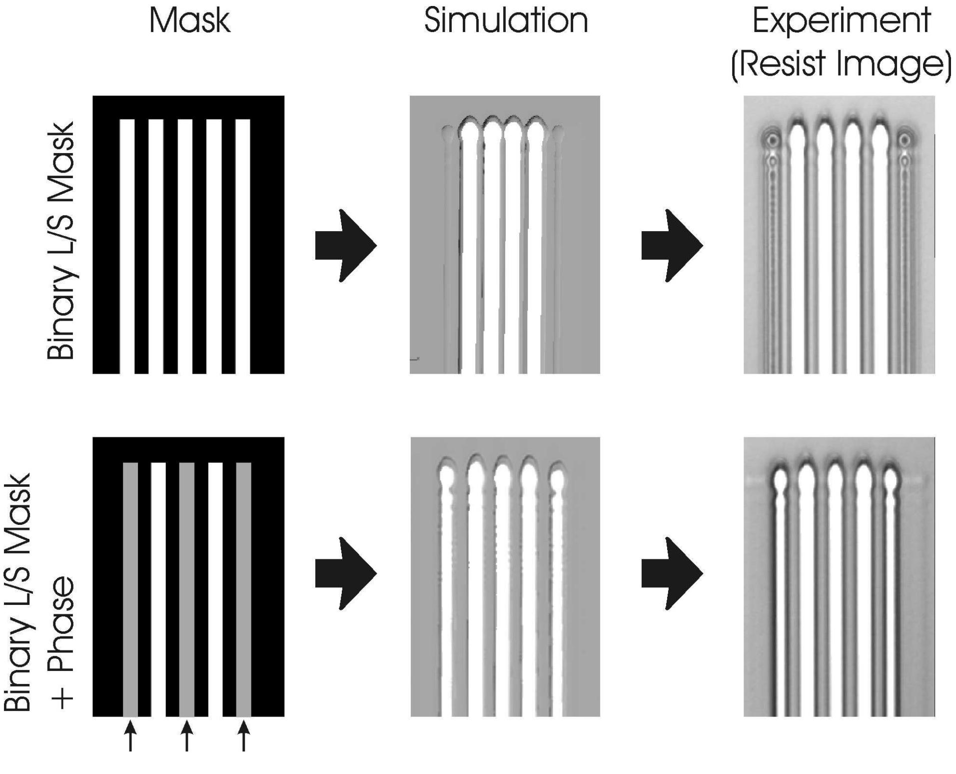

Figure 2: Resolution enhancement using an alternating aperture phase shift mask (AAPSM) for 2 µm L/S printed 30 µm exposure gap. The diffraction effect is clearly seen using a standard binary L/S mask pattern (top), whereas additional alternating phase structures (gray lines with arrows) eliminate the diffraction effect (bottom).