Image-based EUVL Aberration Metrology

Germain Fenger, Bruce W. Smith
Rochester Institute of Technology, Microsystems Engineering
77 Lomb Memorial D., Rochester, NY 14623

Extreme ultraviolet lithography (EUVL) is faced with many challenges. One of those challenges is the measurement and monitoring of aberrations at the sub-nm level. It is anticipated, for example, that the level of absorption by reflective mask and optical elements can lead to variation of aberration levels over time. It is therefore crucial to have in-situ wavefront aberration monitoring which is compatible with full system use. Scatterometry methods can have challenges related to their use, including having a reliable and repeatable detector. An independent method of wavefront aberration monitoring is therefore beneficial, the most practical and available approach being one based on well characterized photoresist imaging.

Resist based aberration metrology can take on many forms such as a Shack-Hartman method based on pupil sampling, phase artifact approaches of mapping the objective lens pupil, or approaches of fitting image data by iterating the pupil wavefront description. The approach that will be presented here is a combination of the latter two, where unique phase and binary mask structures will be used to produce corresponding photoresist images through EUV exposure. This will be combined with dense lithography simulations. The method utilizes a detection algorithm to determine the contour in resist and multi-domain modeling to process the simulated images, creating a database for each feature with exposure and focus variation. The simulated and experimental results are compared and iteratively solved for Zernike polynomial representation of the wavefront. Using this method and the appropriate choice of unique targets, accuracy on the order of half a nanometer rms can be expected.

The study initially limits test targets to binary structures as phase shifted targets and associated masks for EUV application are under development. Although binary structures do not allow for full pupil mapping without the additional phase content of a phase shift mask, through appropriate design they can lead to primary and some high order aberration fitting of the lens pupil to levels necessary to be useful. Several binary structures are investigated and selected based on their sensitivity to specific types of aberrations, up to at least Z_{10}. The binary targets that are investigated are dense and isolated line/ space patterns in various orientations, isolated holes, checker-boards, abutting line ends, and box in box features. Subsets of these binary structures are simulated with a representative aberrated wavefront through focus. EUV imaging parameters have been chosen to correspond to existing and next generation lithography systems.