

A focus vernier for optical lithography

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ABSTRACT

As the depth of focus of optical steppers grows smaller, it becomes more important to determine the position of best focus accurately and quickly. This paper describes the use of phase-shifted mask technology to form a focus vernier: a phase pattern on the stepper reticle which, when imaged in resist, can give both the magnitude and the direction of the focus error. In this, the focus vernier structure is analogous to a 3 overlay vernier. Thus the determination of focus error can be treated as an alignment problem in the z-axis. This technique is an improvement on previous schemes for the determination of best focus from resist images as it can indicate both the magnitude of the error and its direction in a single exposure.

Terawasa et al showed that phase shifter angle errors at the reticle could result in focus shifts of the aerial image of a contact hole. This effect can be exploited to compensate for loss of focal depth due to circuit topography or other systematic deviations in planarity.

Using the lithography simulator, FAIM, we show that this effect is strongly dependent on the relative size of the feature compared to λ/NA , the partial coherence of the illumination, the size, spacing, and the phase angle of the auxiliary shifters. The simulator is used to help design focus sensitive phase structures, tailored to high NA i-line steppers.

In addition, we will give experimental results from a phase-shifted reticle employing focus vernier structures.