Using aberration test patterns to optimize the performance of EUV aerial imaging microscopes

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The SEMATECH Berkeley Actinic Inspection Tool (AIT) is a prototype EUV-wavelength zoneplate microscope that provides high quality aerial image measurements of EUV reticles.[1] In the AIT, it is possible to select up to five different objective lenses with different numerical aperture and magnification values. To achieve the best possible performance in terms of contrast, measurement repeatability and image resolution, the optical alignment plays a central role. Alignment is especially important in the AIT where the "sweet spot" of the field of view is relatively small, approximately 5 μm diameter.

While switching between lenses in the AIT is rather easy (requiring less than two minutes), achieving the highest imaging performance requires a quick and reliable alignment procedure. The first step to optimize the alignment of an optical system is to model and quantify its aberrations within the field of view, and to understand the aberration dependencies on the available degrees of freedom. Ray-tracing modeling provides an accurate map of the field of view as it would be expected to appear in an ideal system, and reveals how the aberrations grow when the alignment parameters are changed. With that in mind an effective strategy for minimizing the aberrations of the system is to compare the measured aberrations with simulations and utilize the alignment parameters that have the strongest effect on the aberrations. In the AIT, the illumination angle, and the zoneplate position are the most sensitive alignment parameters. Our only feedback comes from measurement of the field-dependence of measurable aberrations.

To simplify and improve the alignment procedure we have created and tested arrays of aberration-sensitive patterns on EUV reticles (see Fig. 1). We will discuss various techniques available for different illumination conditions, for matching the measured through-focus test pattern images with model data, to achieve quantitative aberration measurement and improved AIT alignment.

Keywords: EUV, actinic, mask inspection, zoneplate, aerial image, aberrations

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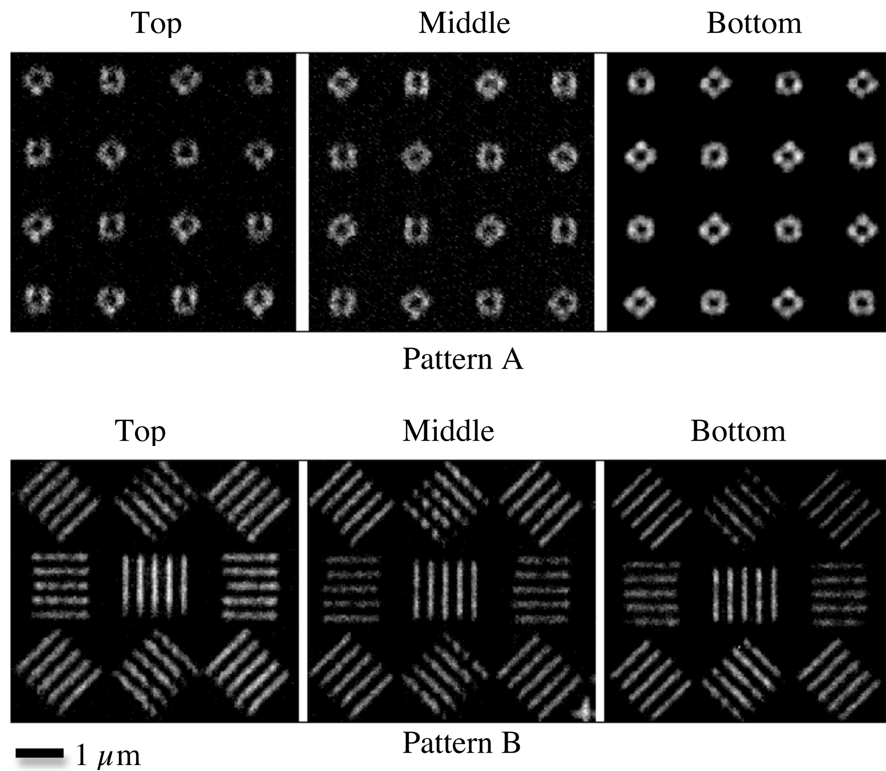

Fig 1. Aberration pattern samples recorded at best focus in different regions of the field of view (top, middle and bottom). A 0.35-NA, 4×-equivalent zoneplate lens was used (mask-side NA value is 0.0875). Pattern A is specifically sensitive to coma, while pattern B is widely used to detect the presence of astigmatism. Other patterns with different characteristics have been used.