Evaluating EUV Mask Pattern Imaging with Two EUV Microscopes

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Aerial image measurement plays a key role in the development of patterned reticles for each generation of lithography. Studying the field transmitted (reflected) from EUV masks provides detailed information about potential disruptions caused by mask defects, and the performance of defect repair strategies, without the complications of photoresist imaging. Furthermore, by measuring the continuously varying intensity distribution instead of a thresholded, binary resist image, aerial image measurement can be used as feedback to improve mask and lithography system modeling methods.

Interest in EUV, *at-wavelength*, aerial image measurement lead to the creation of several research tools world-wide. These tools are used in advanced mask development work, and in the evaluation of the need for commercial at-wavelength inspection tools. We describe performance measurements of two such tools, inspecting the same EUV mask in a series of benchmarking tests that includes brightfield and darkfield patterns.

One tool is the SEMATECH Berkeley Actinic Inspection Tool (AIT) operating on a bending magnet beamline at Lawrence Berkeley National Laboratory's Advanced Light Source. The AIT features an EUV Fresnel zoneplate microscope that emulates the numerical aperture of a 0.25-NA stepper, and projects the aerial image directly onto a CCD camera, with 700x magnification. The second tool is an EUV microscope (EUVM) operating at the NewSUBARU synchrotron in Hyogo, Japan. The NewSUBARU tool projects the aerial image using a reflective, 30x Schwarzschild objective lens, followed by a 10–200x x-ray zooming tube. The illumination conditions and the imaging etendue are different for the two tools.

The benchmarking measurements were used to determine many imaging and performance properties of the tools, including resolution, modulation transfer function (MTF), aberration magnitude, aberration field-dependence (including focal-plane tilt), illumination uniformity, line-edge roughness, and flare. These measurements reveal the the current state of the art in at-wavelength inspection performance, and will be a useful reference as performance improves over time.

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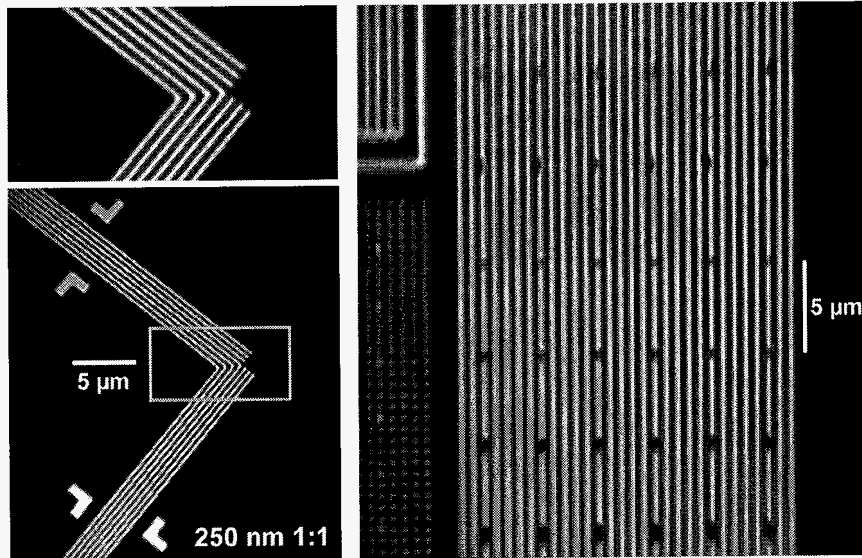

Figure 1. Sample images from the SEMATECH Berkeley Actinic Inspection Tool (AIT).

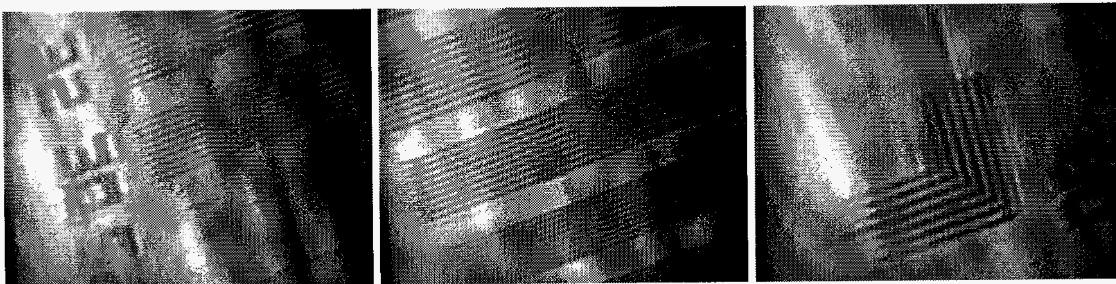

Figure 2. Sample images from the EUV Microscope (EUVM).

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