Wavelength Specific Reflections: A Decade of EUV Mask Inspection Research

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Mask inspection is essential for the success of any pattern-transfer lithography technology, and EUV Lithography in particular faces unique challenges. EUV masks' resonant-reflective multilayer coatings have a narrow, wavelength-specific response that dramatically affects the way that defects appear, *or disappear*, at various illuminating wavelengths. Furthermore, the ever-shrinking size of "critical" defects limits the potential effectiveness of DUV inspection techniques over time. To meet these challenges at-wavelength, numerous ideas and solutions have been proposed and tested.

Over the past fifteen years, many groups have dedicated their research efforts toward the inspection of EUV masks, trying different configurations and geometries, all with similar goals of locating tiny defects, assessing the size-dependent importance of buried, *phase defects*, and evaluating repair strategies. Compounding the challenges, the differences between blank and patterned mask inspection are significant enough to warrant separate approaches, separate tools.

Ranging from basic research and demonstration experiments to commercial inspection tool prototypes, this presentation will survey the recent history of work in this area, including more than a dozen projects in Europe, Asia, and America. From scanning beams to microscopy, dark field imaging to pattern transfer, many techniques have been put into practice. I will review the challenges, and discuss the available methods, all illustrated by their best results.

The presentation will also cover recent highlights from the SEMATECH Berkeley Actinic Inspection Tool, an EUV-wavelength aerial-image microscope dedicated to photomask inspection. Measurements include recent learning from phase defects in blank and patterned masks, early work with EUV optical proximity correction, quantitative observations of multilayer phase roughness, aerial-image line-edge roughness, and more.

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