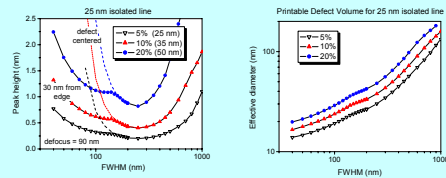


## Abstract

The ability to inspect for defects on EUVL mask blanks is key to the successful development of EUV lithography. Confocal scanning optical microscopy is a promising inspection technique and first generation tools are commercially available. In this work a model for confocal imaging has been developed. The calculated images of PSL spheres on both fused silica and multilayer-coated blanks are in excellent agreement with measurements made on a microscope operating at a wavelength of 488 nm. The model is used to predict the gain in sensitivity for a next generation microscope operating at a shorter wavelength.

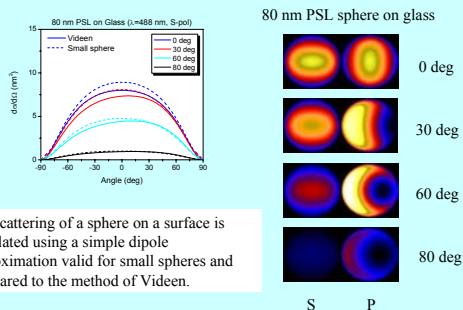
## EUV Printability of Gaussian Phase Defects



The peak height versus width (FWHM) of Gaussian defects which produce a 5%, 10% or 20% increase in line width at the edge of focus, 90 nm defocus for a 25 nm line. The figure on the right uses the same results but shows the diameter of a sphere with the same volume as the Gaussian defect.

E.M. Gullikson, E. Tejnil, T. Liang, A.R. Stivers, SPIE Vol. 5374, 791 (2004).

## Light scattering from a sphere on a surface

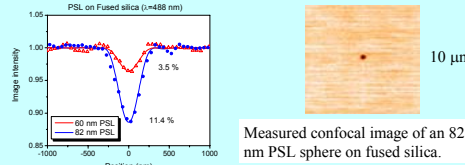
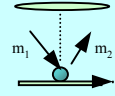


The scattering of a sphere on a surface is calculated using a simple dipole approximation valid for small spheres and compared to the method of Videen.

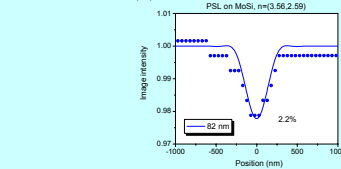
## Confocal imaging of a sphere on a surface

The confocal image field is calculated by integrating the scattering amplitude over all possible directions for the incident and scattered light.

$$U(x) = \iint P(m_1)P(m_2)S(m_1, m_2)e^{-ik(m_1 - m_2) \cdot x} dm_1 dm_2$$

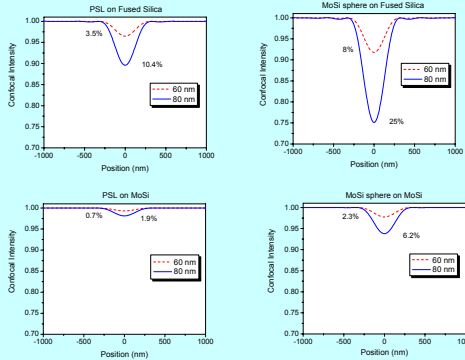


Measured confocal image of an 82 nm PSL sphere on fused silica.



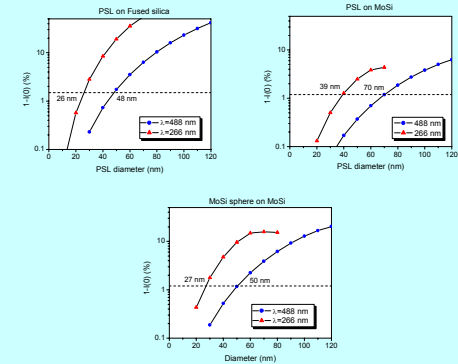
Excellent agreement is obtained for PSL spheres on both fused silica substrates and on Mo/Si multilayer coated mask blanks.

## Predicted Sensitivity



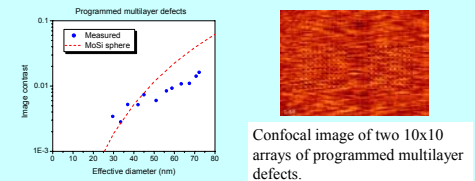
The calculated confocal image intensity for PSL and MoSi spheres on fused silica and MoSi substrates. The MoSi spheres produce a stronger image than PSL and either type of sphere produces a stronger image on fused silica than on MoSi.

## Predicted Sensitivity at λ=266 nm



The dip in confocal image intensity is plotted versus sphere diameter for the present microscope operating at 488 nm and a microscope operating at 266 nm. The horizontal line in each plot is the experimentally determined threshold for 90% capture rate on the 488 nm tool. Reducing the wavelength to 266 nm with all else being the same reduced the minimum detectable particle size to the 25-30 nm range.

## Programmed Multilayer Defects



The measured contrast of programmed multilayer defects is similar to that expected for a MoSi sphere with the same volume as Gaussian bumps.

## Summary

A model has been developed for the confocal image contrast of a spherical particle on a surface. The model has been validated with measurements on a Lasertec M1350 tool. The model was used to predict the improvement in contrast that can be expected for a next generation tool operating at a wavelength of 266 nm.