



COLLEGE OF NANOSCALE
SCIENCE & ENGINEERING

UNIVERSITY AT ALBANY State University of New York



Effect of out-of-band light on optics and mask contamination

INVENT
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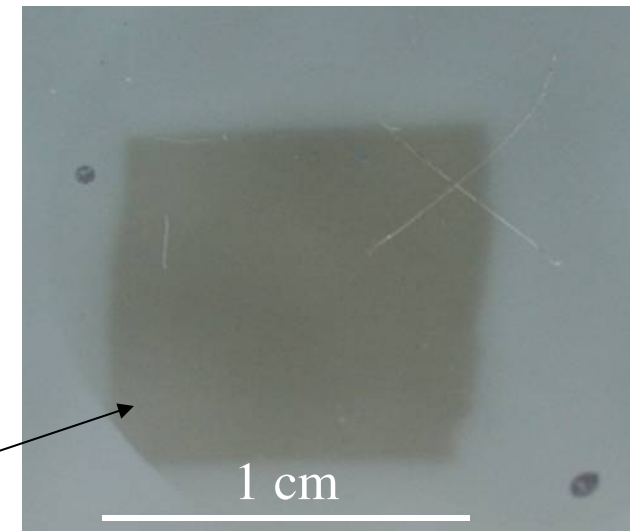
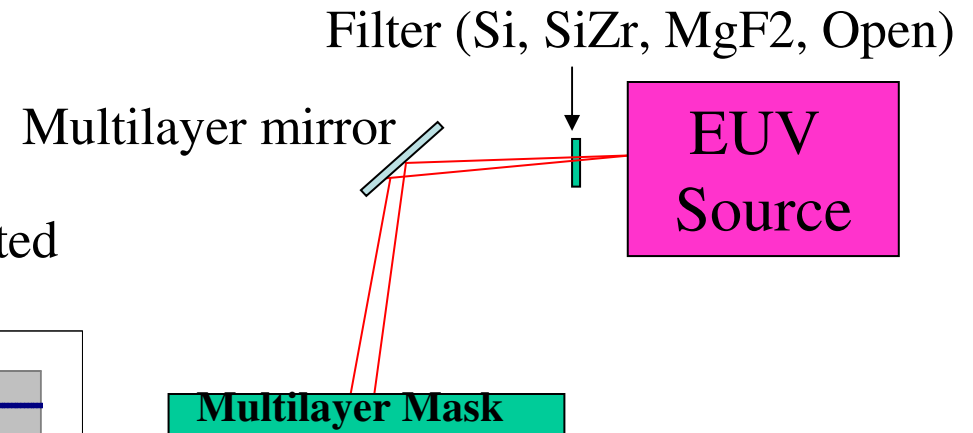
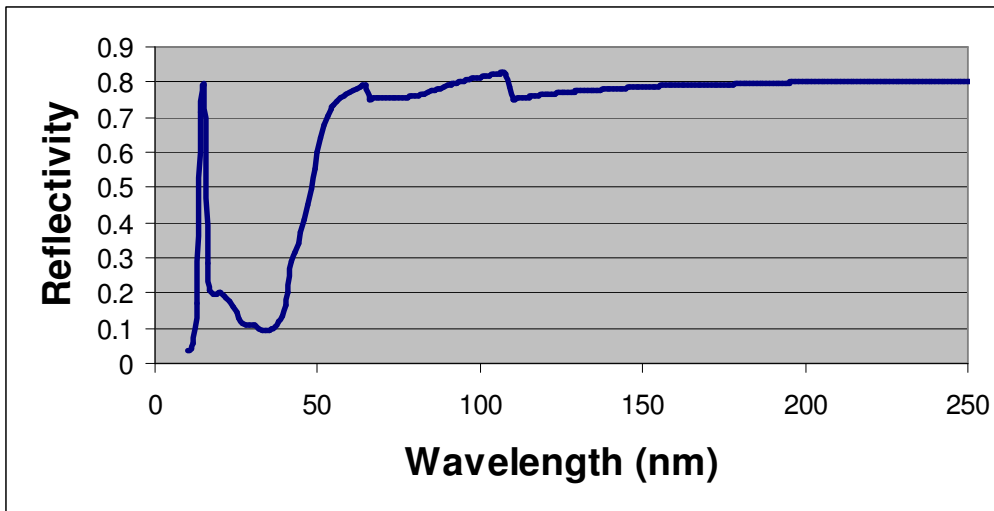
gdenbeaux@uamail.albany.edu

Contamination in EUV exposure tools

- There are published reports of contamination in the illuminator optics in EUV exposure tools
 - Why is this illuminator contamination so much worse than expected?
 - Why is the contamination in the illuminator and not the projection optics?
- There are large differences in contamination tests performed in different systems
 - Why are the test results so different between tools?
- We think that the results of our testing in the MiMICS tool help answer these questions

Removing the filter caused rapid contamination!

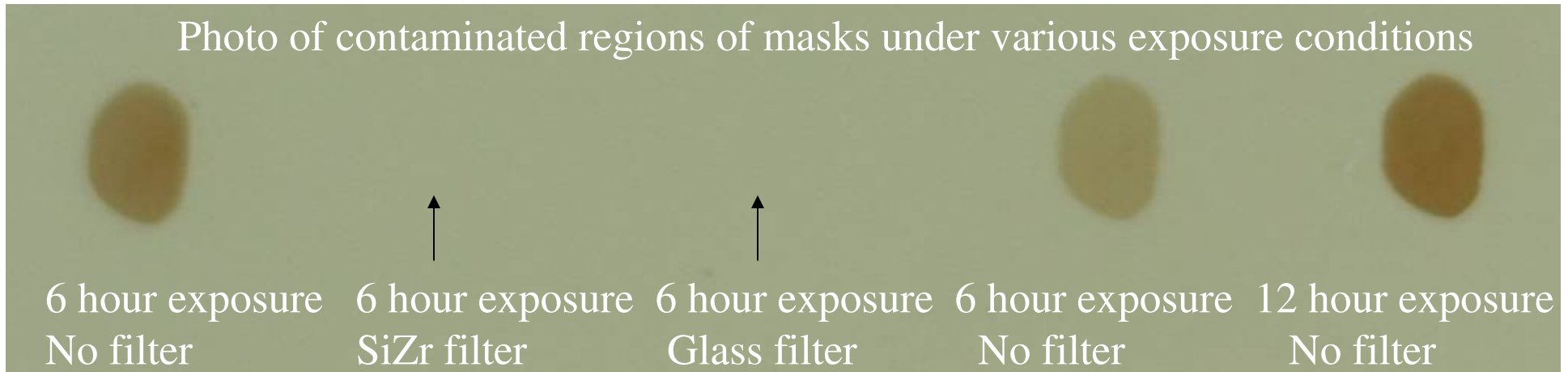
All tests shown will be for a mask illuminated
after reflection from a Mo/Si mirror



Rapid contamination from exposure without a filter
Photo of carbon contamination on mask

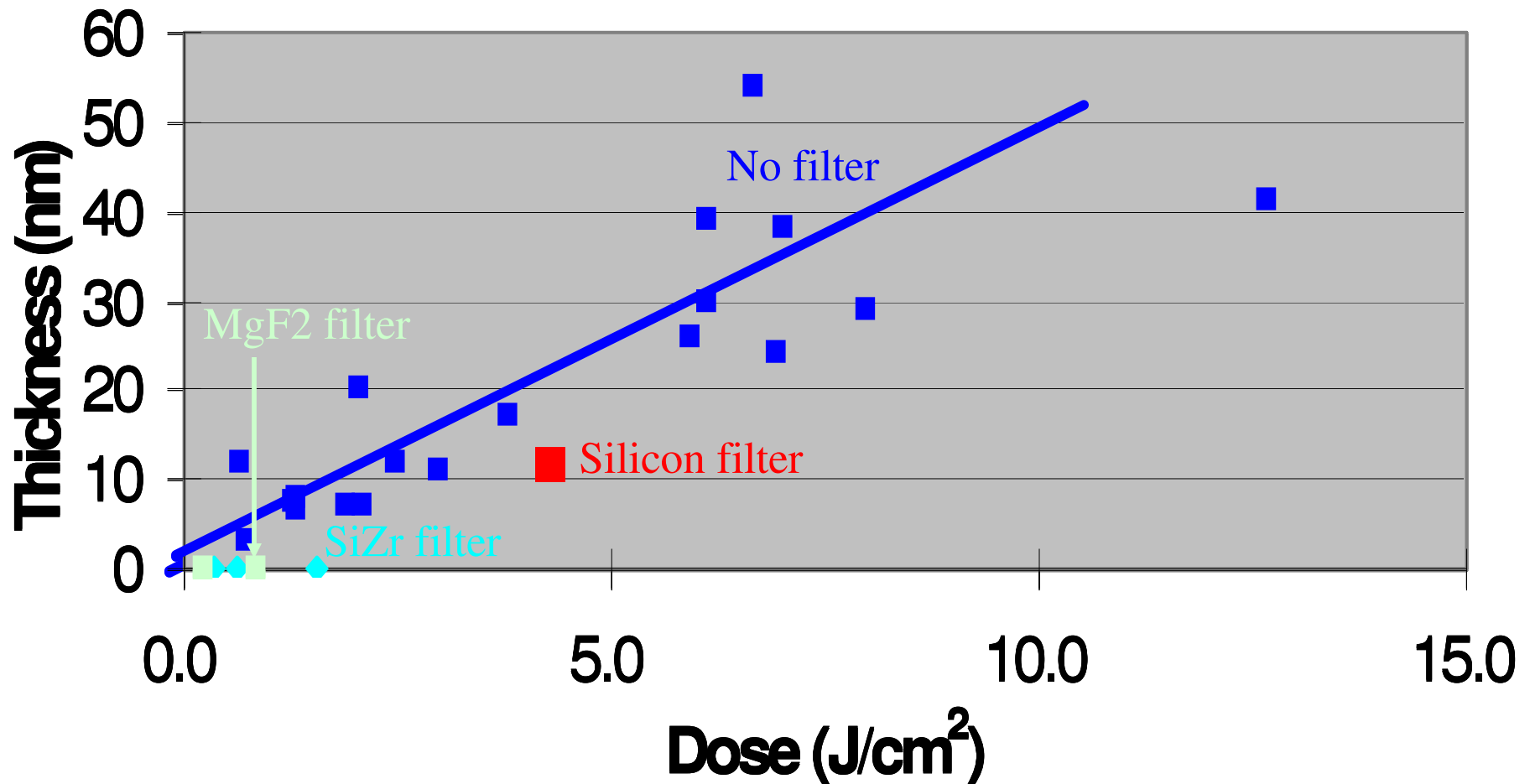
Wavelength dependence

Photo of contaminated regions of masks under various exposure conditions



- There is a clear effect of wavelength on the contamination rate
- EUV light (SiZr filter) does not show a high rate!

Contamination with various filters



Measured Contamination rates

<u>Filter used</u>	<u>Wavelengths of exposure (nm)</u>	<u>Contamination rate</u>
None	13, 40-60, 60-120, 120+	5 nm/(J/cm ²)
Si (180 nm)	13, 40-60	2.5 nm/(J/cm ²)
SiZr (180 nm, 150 nm)	13	Low <i>This is .01 nm/(J/cm²) in a cleaner chamber</i>
MgF ₂ (1 mm)	120+	Low

Contamination appears to be dominated by 40-120 nm radiation!

Conclusions

- Removing the Out-of-band radiation significantly reduces the contamination rate
- Removing the hydrocarbons does the same, but may be more difficult
- Why has there been so much variation in contamination tests worldwide?
 - Is it subtle vacuum environments (as has been predicted)?
 - Or, is it subtle spectral purity variations?
 - Is there a difference between contamination from pulsed sources and synchrotrons?
 - Or is this another example of spectral purity variations?
 - Pinholes in filters make a big difference, and membrane filters all get pinholes
- Why is there so much contamination in published reports on illuminator optics
 - Is this the OOB radiation effect we have seen?