UNIVERSITY AT ALBANY
State University of New York

Study of contamination of Mo/Si multilayer mirrors in water and hydrocarbon environment under controlled vacuum conditions

Rashi Garg, Yujen Fan, Justin Waterman, Leonid Yankulin, Gregory Denbeaux
College of Nanoscale Science and Engineering, University at Albany, Albany, NY 12203

Introduction

- In the presence of Extreme Ultraviolet (EUV) radiations and the residual gases in the vacuum chamber, the reflective Mo/Si multilayer optics get contaminated
- Two major competing processes involved in the degradation of the reflective optics are: oxidation of the capping layer or the Mo/Si multilayer and carbonization of the capping layer
  - EUV optics are irradiated using 10W DPP Xe based source from Energetiq under controlled environments of water and hydrocarbons measured using Extrel Quadrupole mass spectrometer. The mirrors are analyzed using X-ray photoelectron spectroscopy (XPS) for surface contaminations
- The photoresist in vacuum when irradiated by EUV light contaminates the optics by carbon deposition on the capping layer due to outgassing and decreases the reflectivity of the mirror
  - ASML's proposed test to expose 300 mm wafer worth of resist is performed using the pulsed source. The Mo/Si witness plate is then analyzed using XPS for surface contamination and reflectometer for change in reflectivity.

Experimental Details

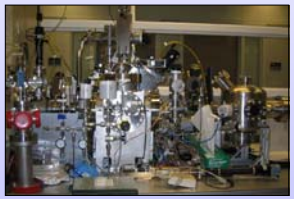
Optics contamination study by bleeding in gaseous materials like water, methanol etc.

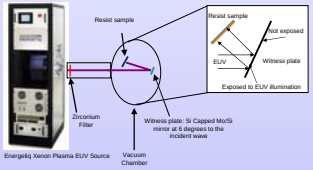
- The vacuum system with gas manifold is used to bleed in gasses for contamination studies and is capable of achieving vacuum below 10^{-8} Torr
- Extrel Quadrupole mass spectrometer provides in-situ measurement of the species and their quantities present in the vacuum chamber
- A magnetically coupled load lock is used for mounting and positioning the optics

Witness plate set-up for exposing 125nm thick PMMA resist samples

- Mo/Si mirror is mounted at 6 degrees to the normal of the source beam
- Dose to clear used for this resist was 20 mJ/cm^2, exposure was done at 2.5 times the dose to clear ~ 50 mJ/cm^2
- Net illumination on the mirror was between 10.5 nm – 15.5 nm
- The number of pulses produced by Xe plasma was 72 million and the dose on the mirror is approximately 160 J/cm2

X-ray photoelectron spectroscopy used for analyzing the surface contamination of the mirrors in both cases



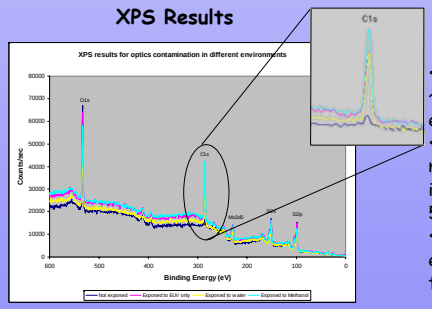


EUV ROX system (EUV Resist Outgassing Exposure System)

Results and Discussions

Optics contamination results

XPS Results



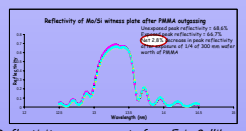
- The XPS signal strength increases by ~ 30% for carbon when the optics are exposed to EUV only
- Exposure in the presence of methanol (which is a source of carbon) increases the signal for carbon by ~ 50%
- Optics exposed under water environment showed similar signal as the one exposed to EUV only

Future and ongoing experiments include:

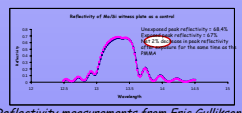
- Reflectivity change measurements
- Similar contamination experiments for different capping layers under different environments

Witness plate results

Reflectometer Results



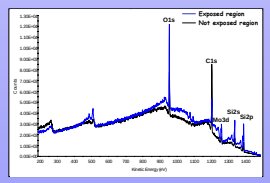
Reflectivity measurements from Eric Gullikson, CXRO



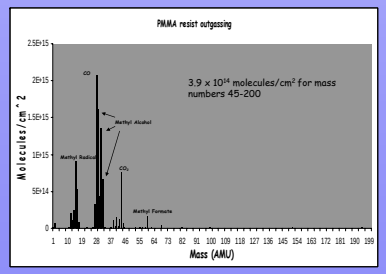
Reflectivity measurements from Eric Gullikson, CXRO

Net peak reflectivity loss due to 1/4th 300mm wafer is 2%, therefore on extrapolating to full 300 mm wafer PMMA, peak reflectivity loss is 3.2%

XPS Results



The XPS results show increase in signal for carbon by ~ 40% after exposure of 1/4th 300 mm wafer of PMMA resist



The mass spectrometer results show 3.9x10^{14} molecules/cm2 outgassed from PMMA which is well above the cut-off

College of Nanoscale Science & Engineering