EUV Stimulated Photo-Resist Outgassing

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1 Introduction

The vacuum environment of an extreme ultraviolet lithography (EUVL) tool must be strictly controlled through the testing and selection of all materials to be applied in the tool. This results in specific partial pressure requirements for the outgassing of water vapour and hydrocarbon species in order to maintain the lifetime of the multilayer mirror projection optics (PO).

The high throughput (100 wafers per hour) of photo-resist coated wafers in an EUVL tool is likely to be the major contribution to the contaminant hydrocarbon partial pressure levels in the PO environment. It is therefore essential to qualify photo-resist materials in a manner akin to the way EUVL materials are tested. The level of outgassing from photo-resist coated wafers has been shown to increase upon stimulation by EUV radiation and it has also been previously shown that 13.5nm irradiation from a pulsed source can give rise to different outgassing rates compared with EUV stimulation from a.synchrotron.

We have measured vacuum outgassing of a photo-resist coated wafer stimulated with high power pulsed 13.5nm EUV radiation, using a quadrupole mass spectrometer (QMS). This work has been performed in collaboration with Energetiq technology Inc. (Woburn, MA, USA) who supplied the pulsed EUV source and is part of a series of 'round robin' measurements requested by the International EUV Initiative (IEUVI) Resist Technical Working Group to compare various outgassing test centres. The photo-resist has been supplied by Massachusetts Institute of Technology Lincoln Labs, and has a clearing dose of 4mJ/cm^2, expected outgassing could include 2-methyl-1-propene, benzene and isobutane, the solvent used during coating was ethyl lactate.

2 Experimental set up

- Outgassing measurements were performed using a 200 amu residual gas analyser.
- The pumping speed at the chamber was approximately 15 l/s. The system base pressure was better than 1x10^{-8} Torr,rising to 5 x 10^{-7} Torr during exposure. The practical sensitivity limit of the RGA was 1x10^{-12} Torr.
- The wafer samples were positioned 90cm from the plasma, at an angle of incidence 45° to both the EUV beam and the RGA.
- Exposures can be performed with the sample under vacuum for varying lengths of time before measuring.

3 Exposure conditions

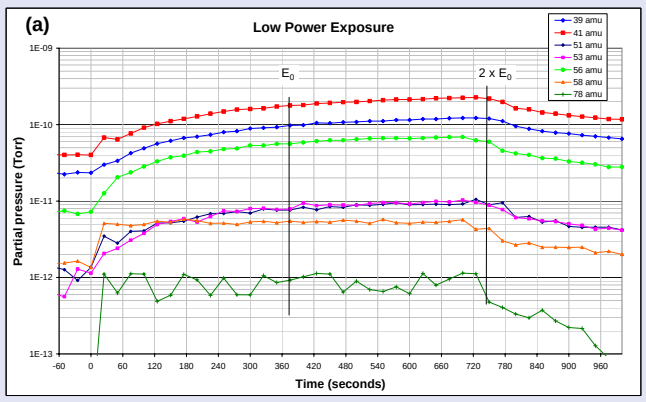
- Measurements were performed using EUV light from an electrodeless z-pinch gas discharge source.
- Exposure conditions:
  - For the low power exposures a dose of 1mJ/cm^2 is reached in approximately 87 seconds exposure.
  - For the high power exposures a dose of 1mJ/cm^2 is reached in approximately 1 second exposure.

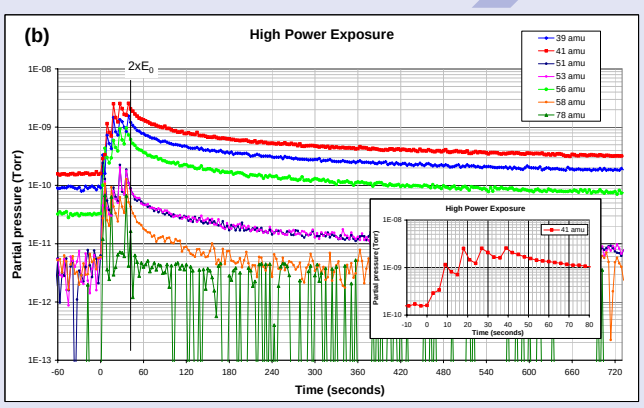
High power exposure is achieved through burst mode operation, 2 second burst with 20% duty cycle.

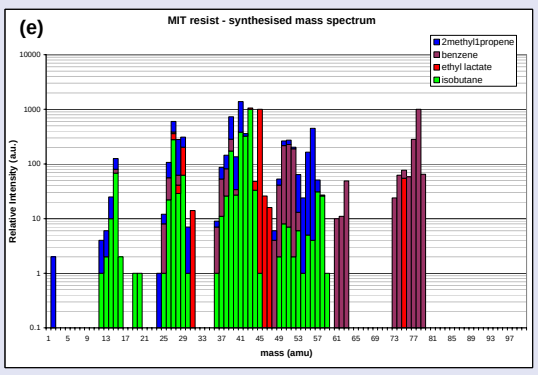
- EUV light was filtered by a 200nm thick zirconium foil, size 1cm^2, resulting in an exposure area at the sample of 0.5cm^2

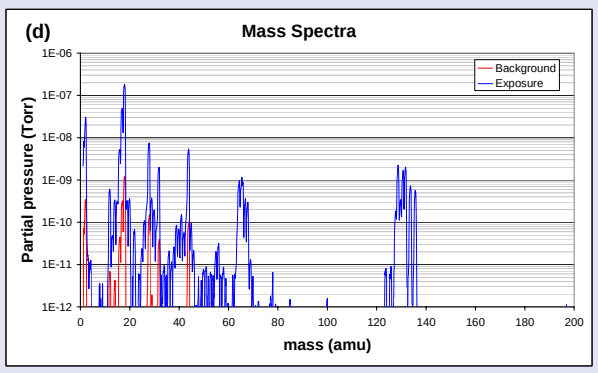
4 RGA Results

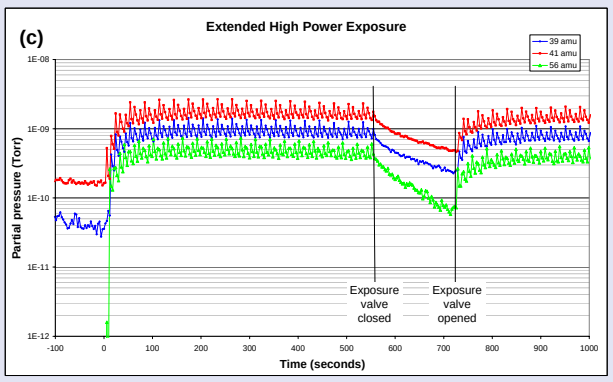
- Time dependent outgassing results
  - Graph (a) shows time dependent outgassing results obtained from a low power exposure.
  - Graph (b) shows time dependent outgassing results obtained from a high power exposure. The inset shows individual burst behaviour.
  - Graph (c) shows time dependent outgassing results obtained during an extended high power exposure
- Graph (d) shows typical mass spectra recorded from the clean system background andduring an exposure.
- Graph (e) is a synthesised mass spectrum of the predicted outgassing species.











5 Preliminary Conclusions

- Specific outgassing has been observed at 39, 41, 43, 51, 53, 56, 78amu under exposure conditions where the sample is under vacuum for a short period of time before measuring, approximately 1 hour.
- The outgassing rate is observed to increase by approximately one decade from 'low' to 'high' power exposure conditions.
- Extended 'high' power exposure displays no significant increase, or decrease, in outgassing rate as a function of time.
- The observed outgassing is consistent with the predicted species, shown in graph (e) above, however it is very difficult to de-convolute the measured data into such a mass spectrum and so we cannot identify all components individually. The presence of 39, 41 and 56amu are likely from of 2-methyl-1-propene. 78amu is characteristic of Benzene. 58amu is evidence of isobutane.
- It has been observed also that there may be some dependence on the time the sample is under vacuum before exposing and measuring. During one series of measurements the sample remained under vacuum for 24 hours before exposure and in this case there was no observable outgassing above 56amu.

6 Acknowledgements, Further information

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