



Measurements of HC Levels in Stepper Vacuums

EUV Optics Contamination and Lifetime Workshop
and IEUVI Resist Technical Working Group Joint Session

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Introduction

- BOC Edwards interest lies in the provision of the appropriate vacuum environment for the EUV tool in order to maintain mirror lifetime
- This environment may include in situ contaminant mitigation strategies to maintain adequate mirror reflectivity
- There is a common thread between the optics & resist communities of trying to understand the impact of resist outgassing on mirror reflectivity
- A proportion of the outgassing budget for the entire tool is allocated to resist outgassing in addition to the outgassing from all the other materials & components within the tool
- Standard methods have been developed to screen materials and make effective comparison & selection of materials
- We believe that our learning from this work can aid the resist outgassing characterisation and the following slides share some of the important considerations...



Background

- The Optics Community needs to understand what levels of resist outgassing result in mirror reflectivity loss
 - This is not a simple problem, as not all hydrocarbon species have the same impact on reflectivity loss
 - In situ reflectivity measurement will be important to understand direct impact
- The Resist Community needs to understand what aspects of the resist formulations give rise to outgassing
 - Species information is valuable using mass spectrometry
 - Information needs to be tool independent
- Suggests the need for a 2 stage qualification process
- Initial process of rapid resist screening, to identify suitable formulations etc. followed by more detailed reflectivity investigations.
 - Rapid screening requires an in-situ, real-time detection of the outgassed species
 - In order to be rapid the detector should also be sensitive
 - Quadrupole Mass Spectrometry is a suitable sensing technology
 - Also provides time dependent information



Measurement repeatability and traceability

- > Standard calibration procedure should be adopted and performed at regular intervals
- > Requirements for calibration process would be
 - Accurate mass alignment and correct mass resolution
 - Leading to measurement of a sensitivity curve which is transferable between different detectors and systems
- > Achieved by using noble gas mixture as reference standard, assuring no cross-contamination with resist species
 - e.g. Ar, Kr, Xe – provides suitable spread of isotopic masses
 - Inert gas mixture is easily pumped away and less contaminating to the ion source compared to per-fluorinated substances (such as PFTBA) more conventionally used for mass spectrometer calibration
 - Delivered at a defined pressure (P) and pump speed (S) in the chamber thereby allowing mass flow (Q) rate to be measured accurately
 - Referring to the simple vacuum equation $Q=SP$
- > Multiple Calibrated leaks from a single standard gas mixture can be manufactured which would be traceable between different measurement systems



Measurement of mass spectrum

- Measurement of the mass spectrum can provide information to assist in quantitative determination of the outgassing rate as well as, more qualitatively, a direct comparison between different resist formulations
 - All ionisation based gauges and detectors have inherent variations in sensitivity to different species, which will introduce errors in any hydrocarbon quantification
- Determination of total outgassing rate that is comparable between different systems requires precise knowledge of measurement conditions
 - EUV intensity, illuminated area, illumination time, measurement time
- Qualitative analysis of outgassing data can be performed by initial measurement of complete, uncorrected, mass spectrum to identify specific outgassing species followed by further time dependent investigations.



Mass spectra interpretation

- Quantitative analysis of outgassing rate - summation approach
 - Sum individual measured partial pressures, above mass 44, across available mass range of the detector
 - Specific non-hydrocarbon related peaks, such as those from the source, should be removed from the overall summation
 - Measured pumping speed at the sample is required, using calibrated pressure gauges
- However, it should be noted that errors in such generally quantified hydrocarbon levels can be significant because
 - not all 'hydrocarbons' have the same contaminating effect on the mirror
 - Ionisation sensitivity factors for 'hydrocarbon' molecules can be as high as 10 relative to nitrogen
- Qualitative analysis of mass spectrum
 - Knowledge of resist formulation can assist in the identification of outgassing species by comparison with cracking patterns in mass spectral databases, such information is useful to feedback into the resist development process