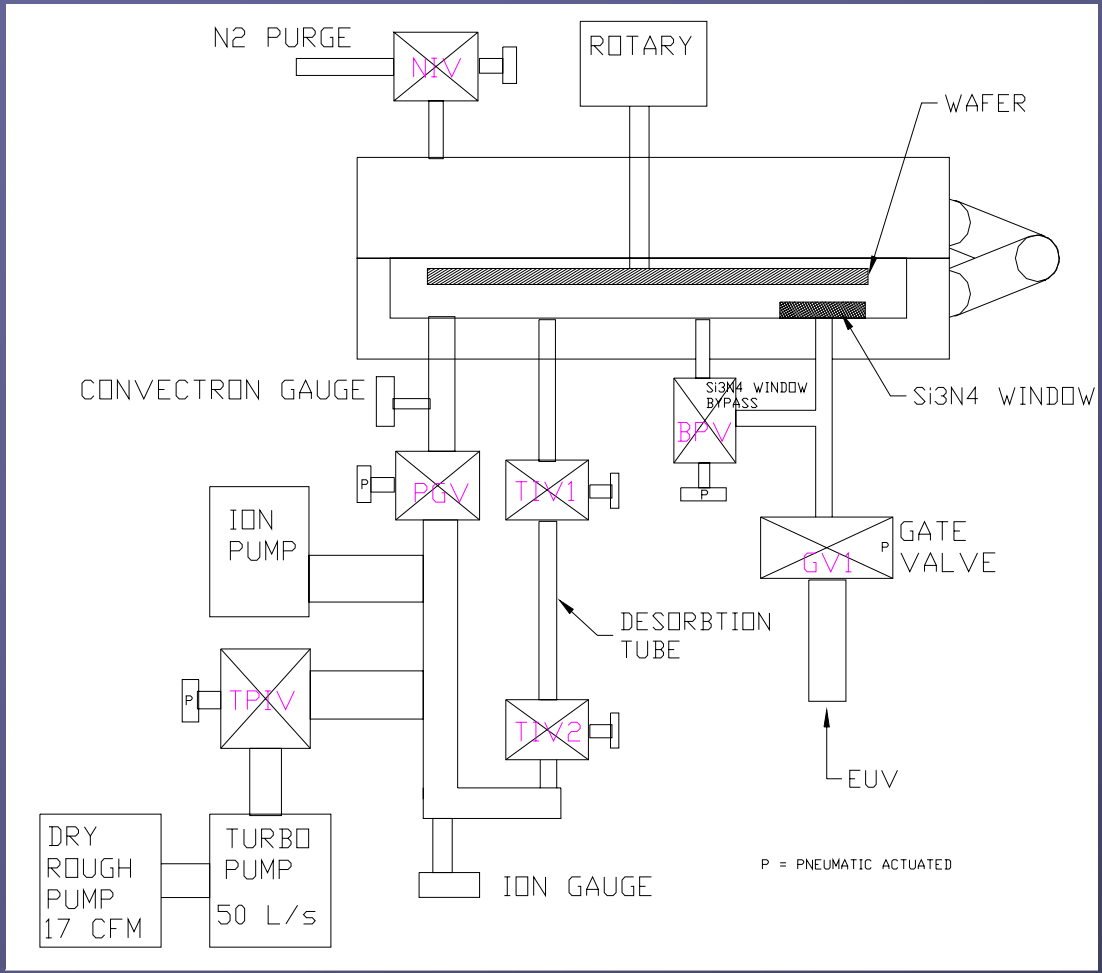
Quantification of EUV Resist Outgassing

Heidi B. Cao, Wang Yueh, Vani Thirumala, Hokkin Choi

Intel Corporation

SPIE 2005, Feb 27 - Mar 4

Experimental set-up



Experimental procedure

- Place resist coated wafer in chamber, and pull vacuum.
- Expose resist to EUV.
- Purge chamber with nitrogen into absorption tube.
- Close valve to absorption tube, and remove wafer.
- Repeat with two additional wafers into a single absorption tube to amplify signal.
- Analyze outgassing contaminants using GC/MS.

Experimental details

- Desorption tubes are packed with a mixture of Tenax and Carboxen resins for sensitivity to hydrocarbons and halogen containing compounds.

- Conversion from area counts to molecules is calculated by introducing a known quantity of an analyte into the GC-MS and characterizing the response.

$$\text{Outgassing Conc (molecules/cm}^2\text{)} = \frac{\text{GC-MS response (Area counts)} \,/\, \text{Response Factor (Area count/molecules)}}{\text{Exposed area (cm}^2\text{)}}$$

- We assume that the response of the outgassing species is equivalent to the response of our known standard (toluene).

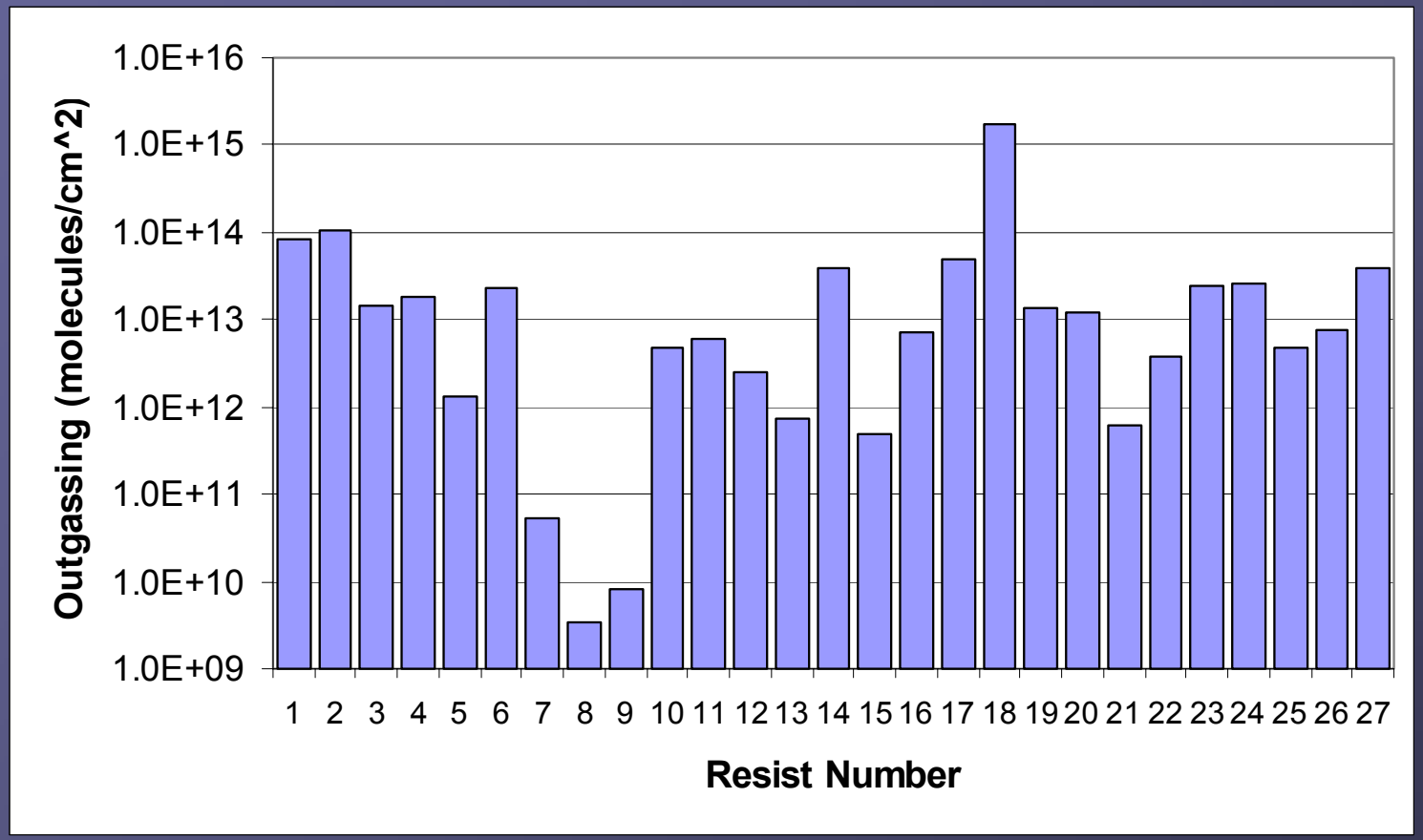
Limit of detection

- Outgassing can be efficiently measured down to levels of 10^{11} molecules/cm^2. Below this level, noise from GC/MS and background contaminants is problematic.

Background Contamination Introduced by:	Most Common Background Contamination Observed
GC/MS and empty desorption tube	Silanes
Empty outgassing chamber	Hydrocarbons
Internal standard	Esters

- For each outgassing sample, the empty desorption tube is pre-screened and an empty chamber sample is taken to characterize the background contamination. The background contamination is not included in the final quantification results.

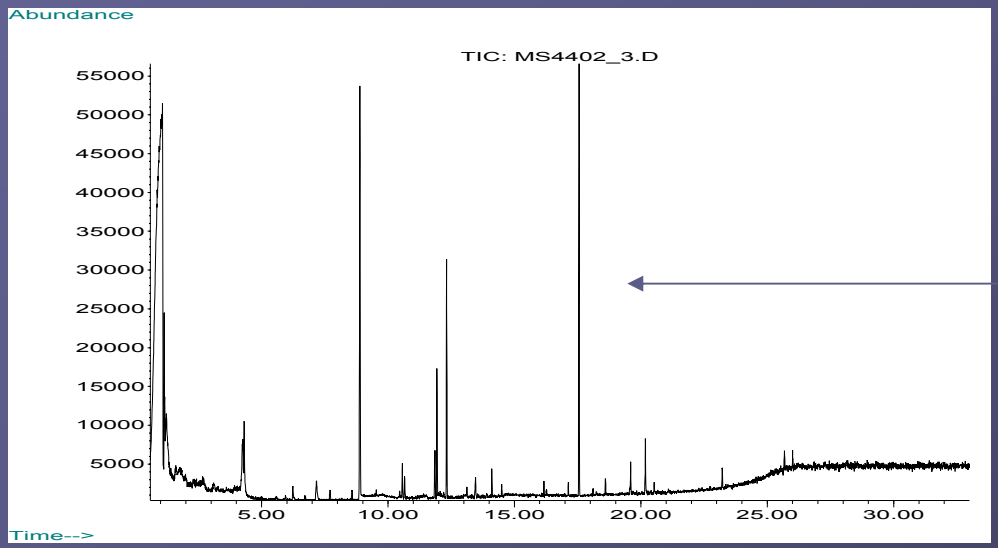
Levels of outgassing



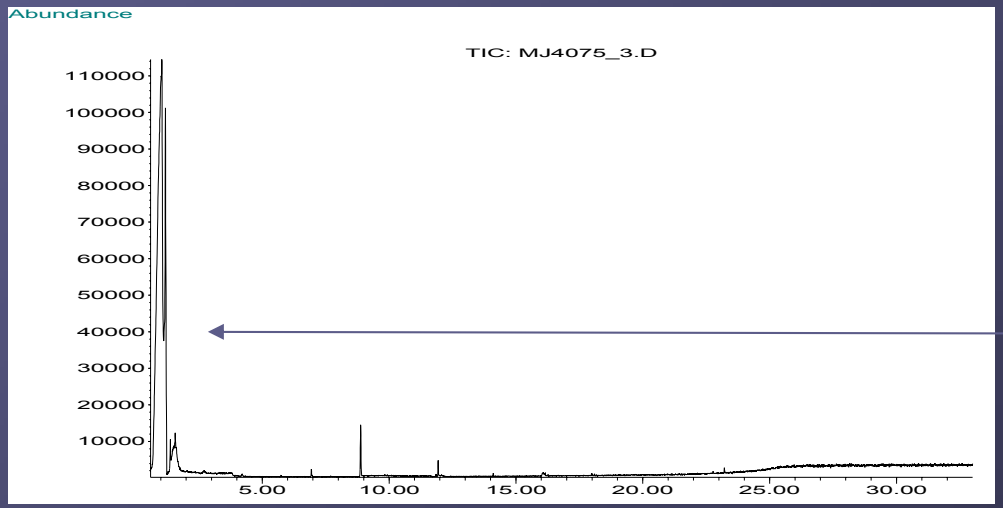
- Resist that have been quantified with outgassing below 10^{11} may not be accurate, since below the detection limit of our technique.

Outgassing results

- **Intel has found the main outgassing contaminants from EUV resists are PAG fragments and protecting groups.**



Evidence of PAG fragment outgassing



Evidence of protecting group outgassing

PAG outgassing

Outgassing results as a function of PAG chemistry:

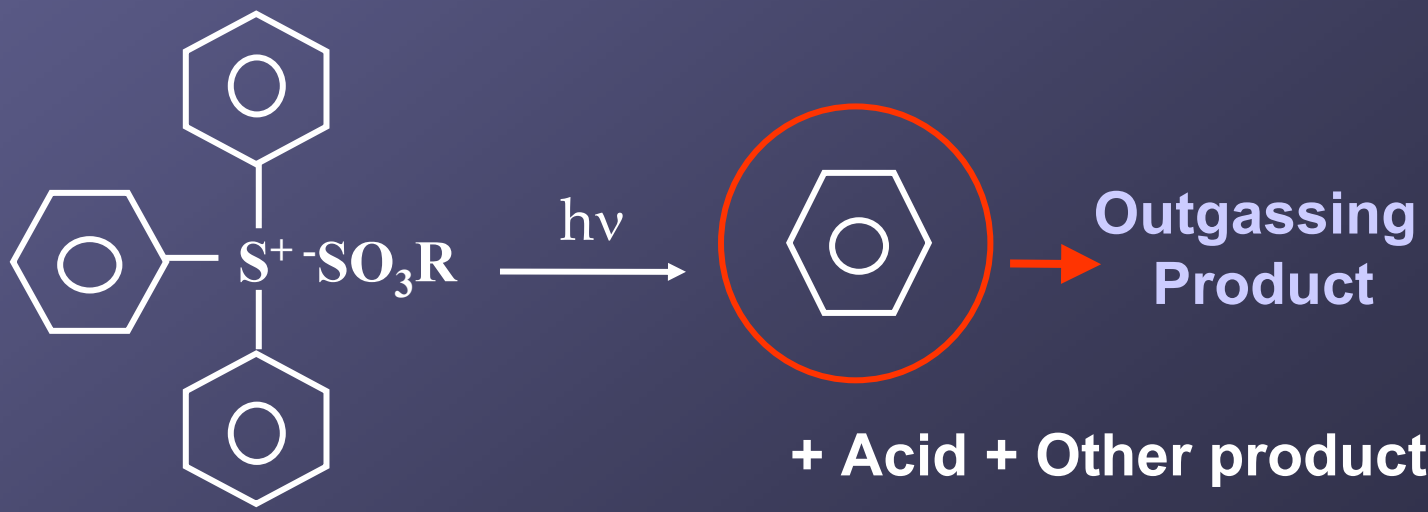
Ionic PAG A
= $1*10^{13}$ molecules/cm^2

Ionic PAG B
= $6*10^{12}$ molecules/cm^2

Non-ionic PAG C
= $6*10^{11}$ molecules/cm^2

Non-ionic PAG D
< 10^{11} molecules/cm^2

Possible outgassing mechanism for an ionic PAG:



+ Acid + Other products

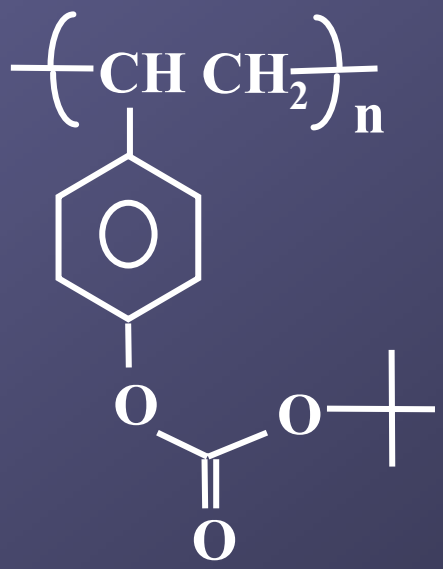
Protecting group outgassing

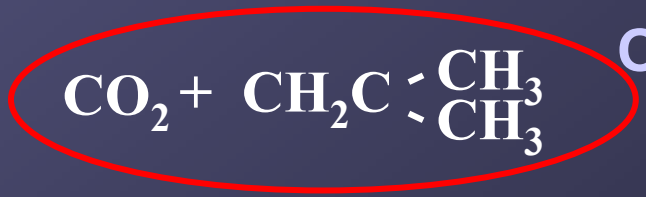
Outgassing results as a function of activation energy (E_{act}) :

Low/medium E_{act} resist E = $4*10^{13}$ molecules/cm^2	High E_{act} Resist G = $7*10^{11}$ molecules/cm^2
Low/medium E_{act} resist F = $2*10^{13}$ molecules/cm^2	High E_{act} Resist H <10^{11} molecules/cm^2

Possible deprotecting group outgassing mechanisms:

T-boc deprotecting group (with medium activation energy) will outgas in EUV.





Outgassing Products

+ Other products