

Quantification of EUV Resist Outgassing

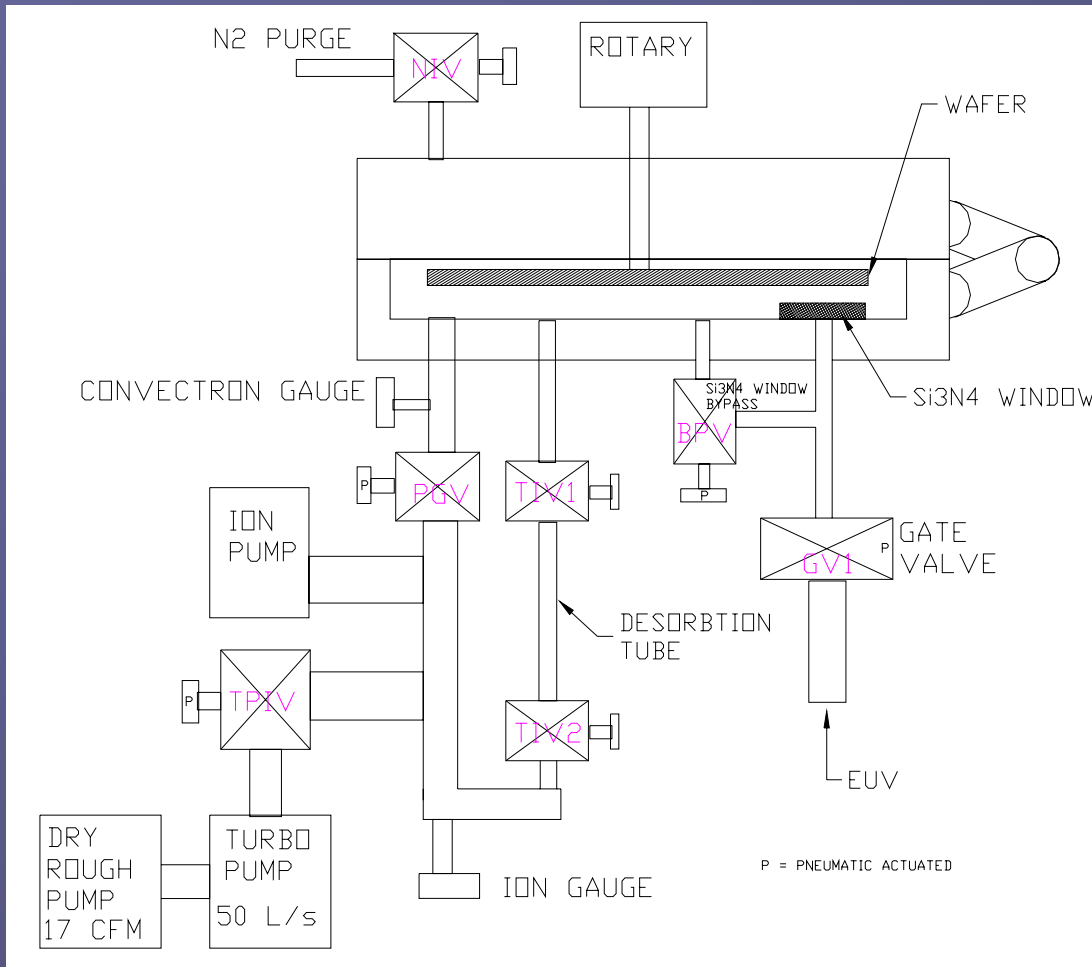
**Heidi B. Cao, Wang Yueh, Vani Thirumala,
Hokkin Choi**

Intel Corporation

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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).

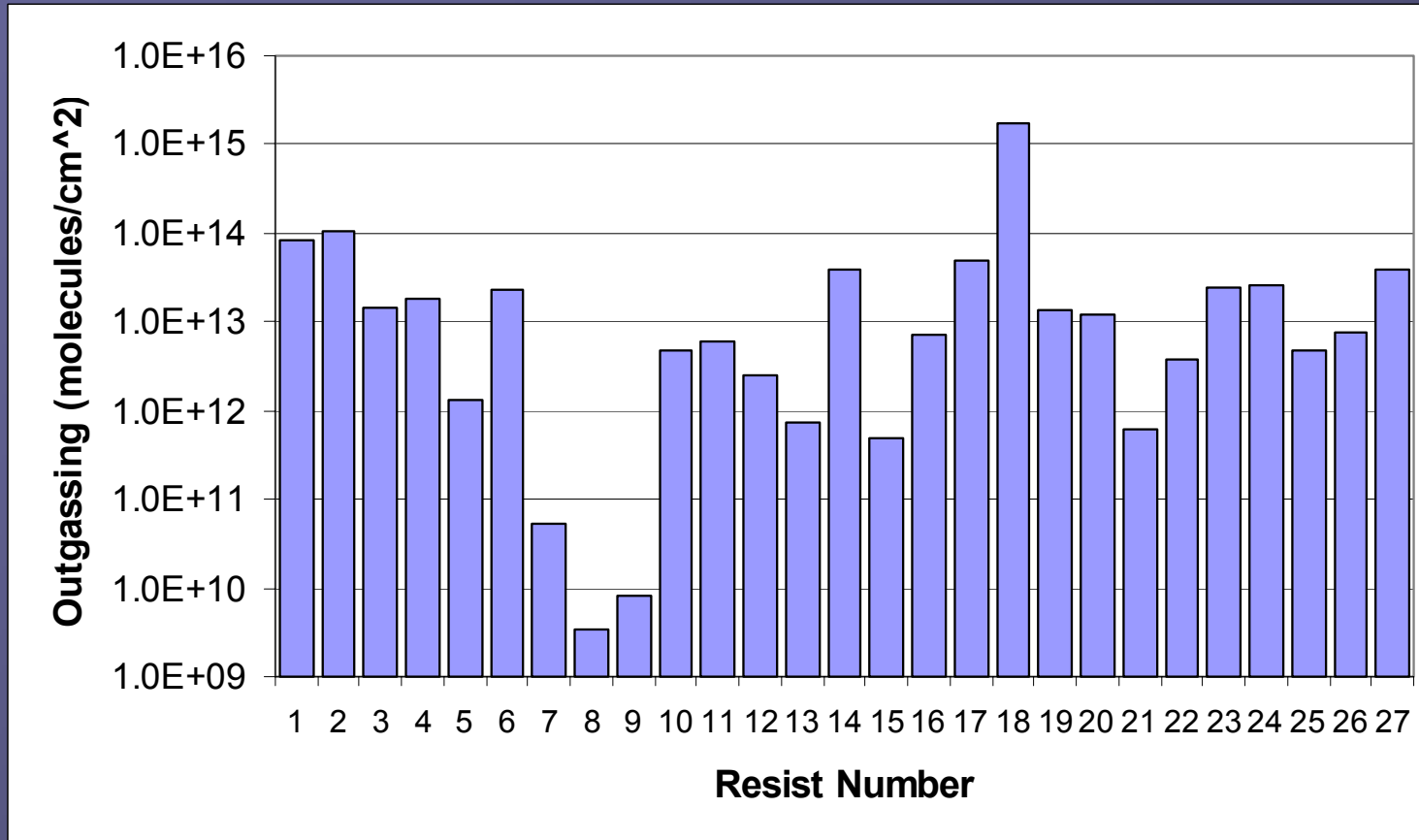
Limit of detection

- Outgassing can be efficiently measured down to levels of 10^{11} molecules/cm². 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.

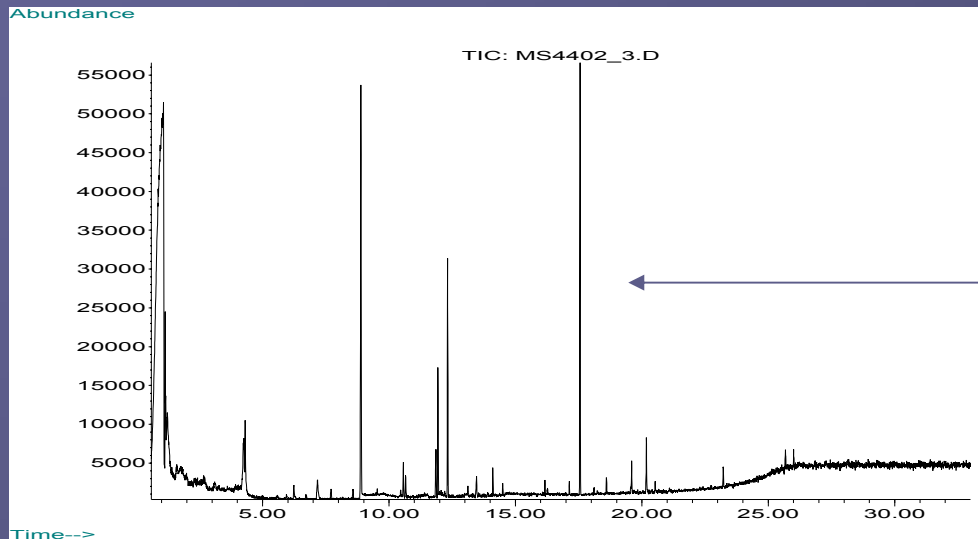
Levels of outgassing



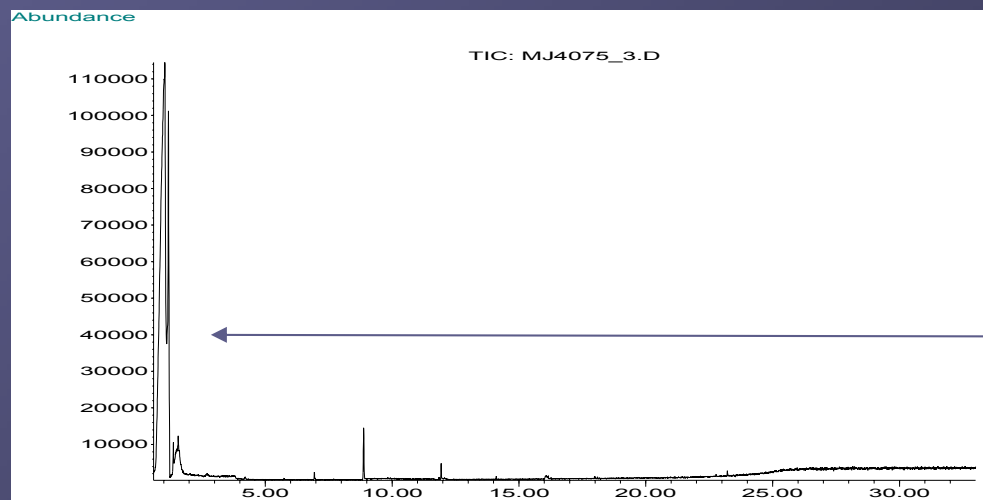
- Resist that have been quantified with outgassing below 10^{11} may not be accurate, since below the detection limit of our technique.

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

$= 1 \cdot 10^{13}$ molecules/cm²

Non-ionic PAG C

$= 6 \cdot 10^{11}$ molecules/cm²

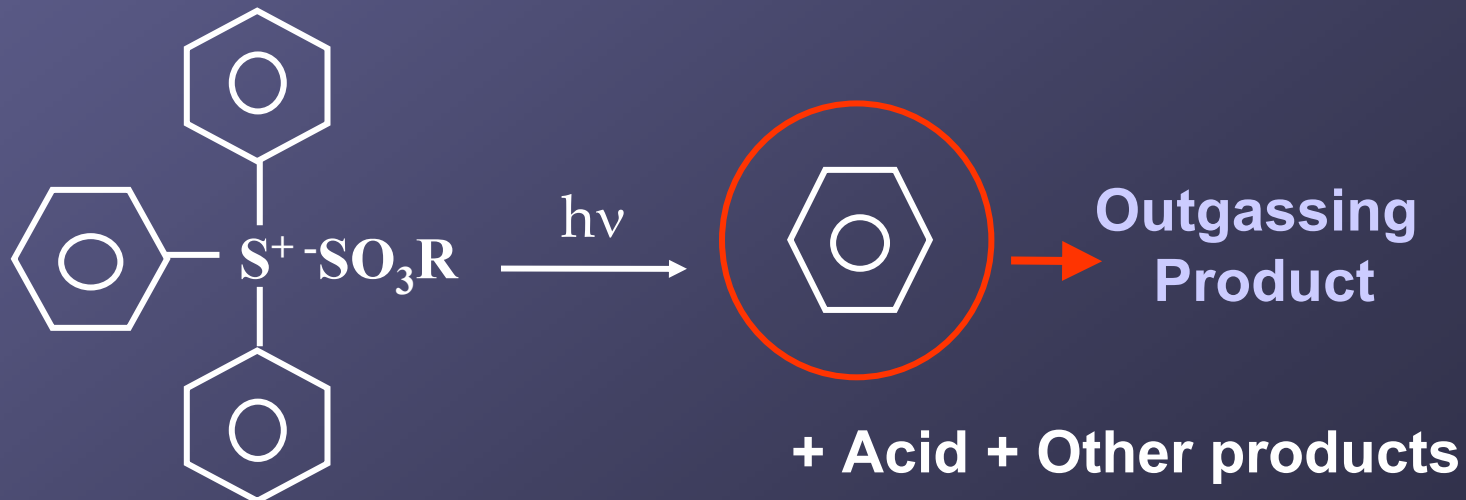
Ionic PAG B

$= 6 \cdot 10^{12}$ molecules/cm²

Non-ionic PAG D

$< 10^{11}$ molecules/cm²

Possible outgassing mechanism for an ionic PAG:



Protecting group outgassing

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

Low/medium E_{act} resist E
 $= 4 \cdot 10^{13}$ molecules/cm²

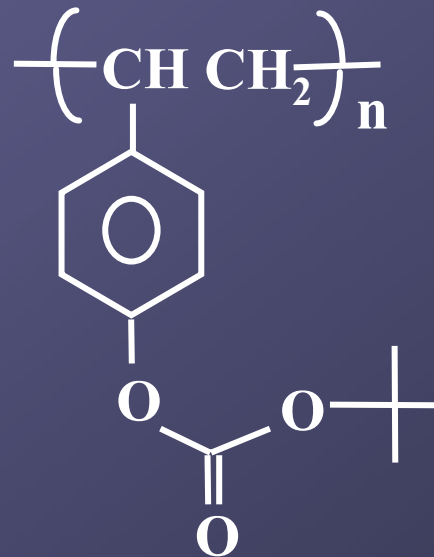
High E_{act} Resist G
 $= 7 \cdot 10^{11}$ molecules/cm²

Low/medium E_{act} resist F
 $= 2 \cdot 10^{13}$ molecules/cm²

High E_{act} Resist H
 $< 10^{11}$ molecules/cm²

Possible deprotecting group outgassing mechanisms:

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



Outgassing
 Products

+ Other products