IMEC UPDATE ON RESIST OUTGASSING QUALIFICATION

I. POLLENTIER, R. LOKASANI, AND R. GRONHEID

OUTLINE

Imec infrastructure and qualification results

Simple RGA approach to quantify cleanable and non-cleanable contamination

Correlation of simple RGA approach to NXE WS results

EUV vs. E-gun resist exposure mode

Summary

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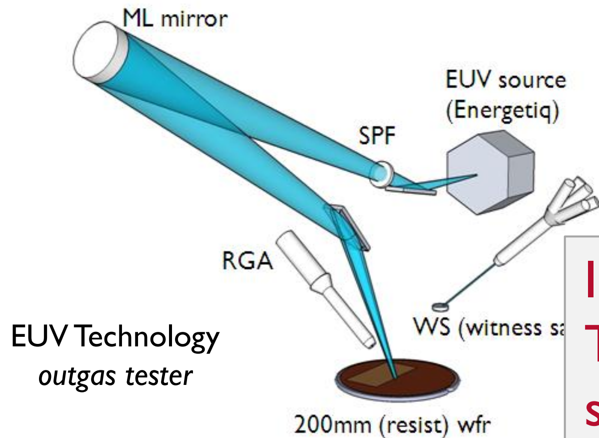
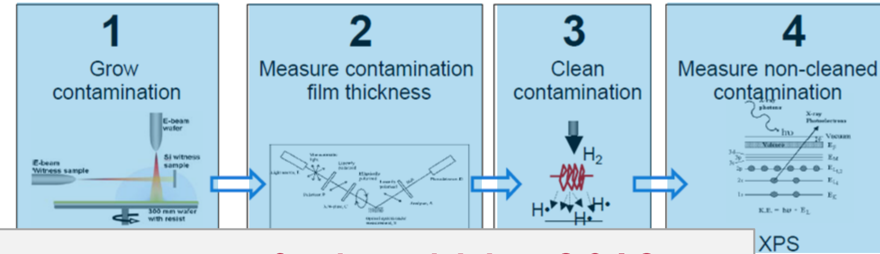
Resist outgassing qualification procedure for NXE3x00

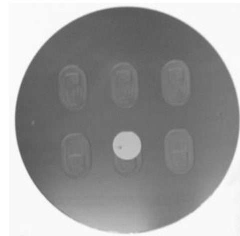


EUV Technology
outgas tester



Imec infrastructure was certified end May 2012.
The issue with H-cleaner sulfur background is solved in August.
Currently, the infrastructure allows to test ~20 materials per month.

KLA-tencor UV1280 *ellipsometer*



200mm Pocket-wafer with 6 available positions for 1" WS

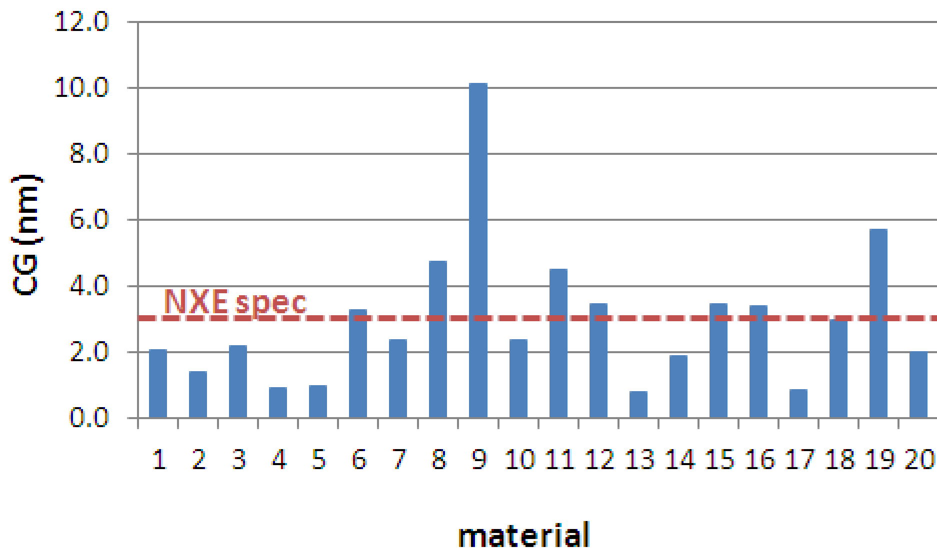
EUV Technology
H-filament cleaner

Thermo Instruments Theta 300
XPS

CURRENT QUALIFICATION RESULTS

Cleanable contamination

- Resist related contamination growth (CG) of 20 resists (commercial and model) was determined using NXE qualification method.



Most commercial materials meet the NXE spec for cleanable contamination (<3nm), but variation of CG thickness can be obtained depending on the chemistry of the (model) resists and its dose.

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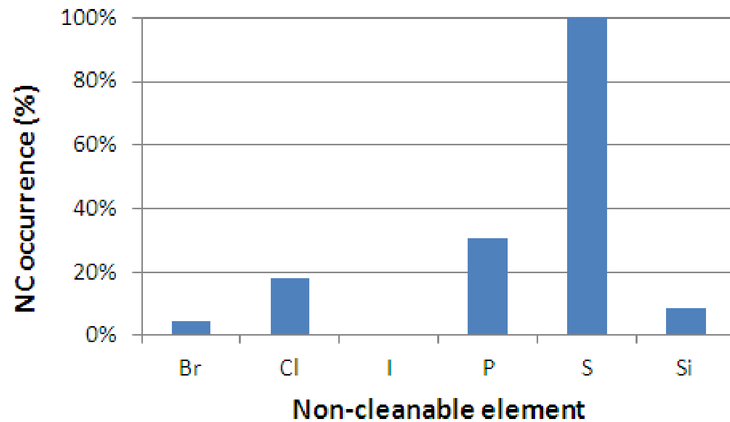
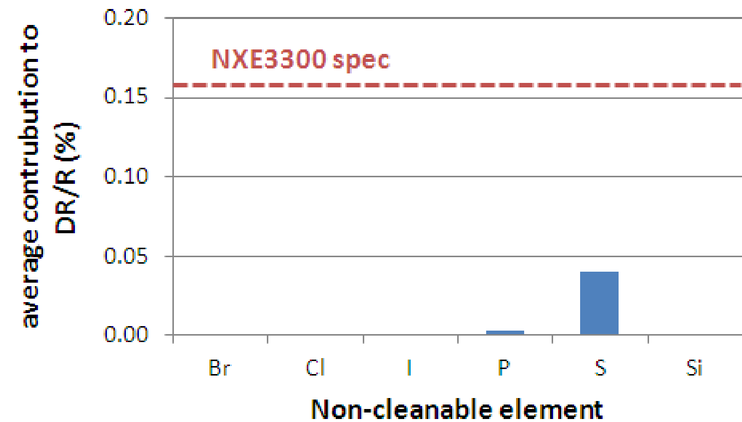
CURRENT QUALIFICATION RESULTS

Non-cleanable contamination

- Resist related contamination of 23 resists (commercial and model) was analyzed by XPS





Sulphur appears consistently in all measurements and has in average the highest contribution. However the typical contribution seems to be significantly less than the NXE300-spec.

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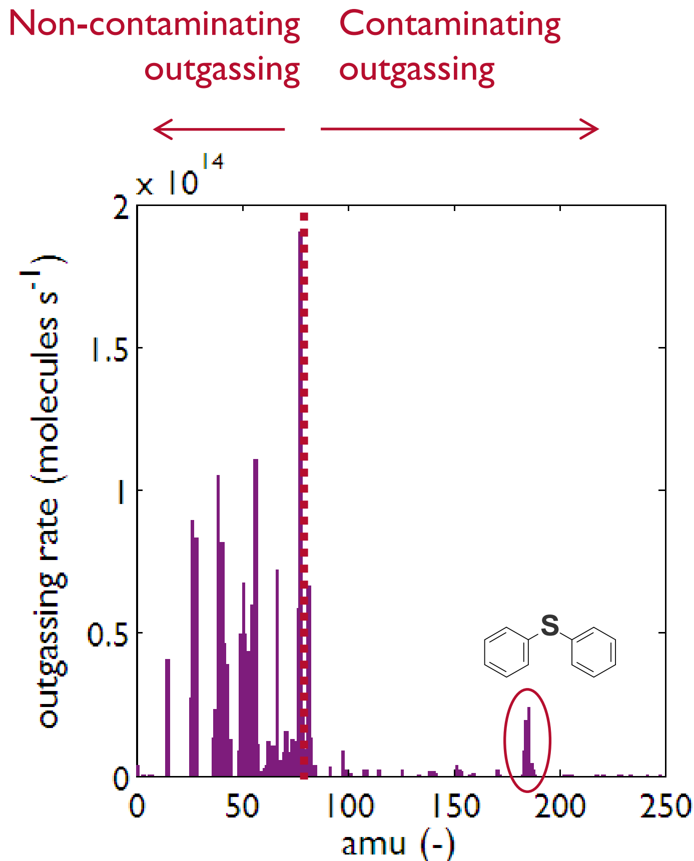
RGA APPROACH FOR TESTING CONTAMINATION

WS testing is very relevant for contamination but gives limited information on the mechanism of outgassing and its relation to contamination



RGA can give continuously information on molecular weight (amu) of species that are outgassing.

Earlier work suggests that mostly high amu species contribute to contamination, while low-amu species do not.
[I. Pollentier et al., Proc. of SPIE vol. 7972 (2011)]

Non-cleanable contamination is typically seen as diphenylsulfide (or comparable) from PAG cation
[I. Pollentier et al., J. Photopolymer Sc. and Techn., Vol 23 (5) (2010)]

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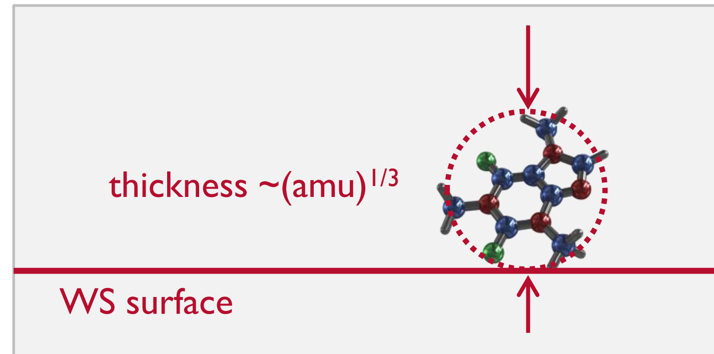
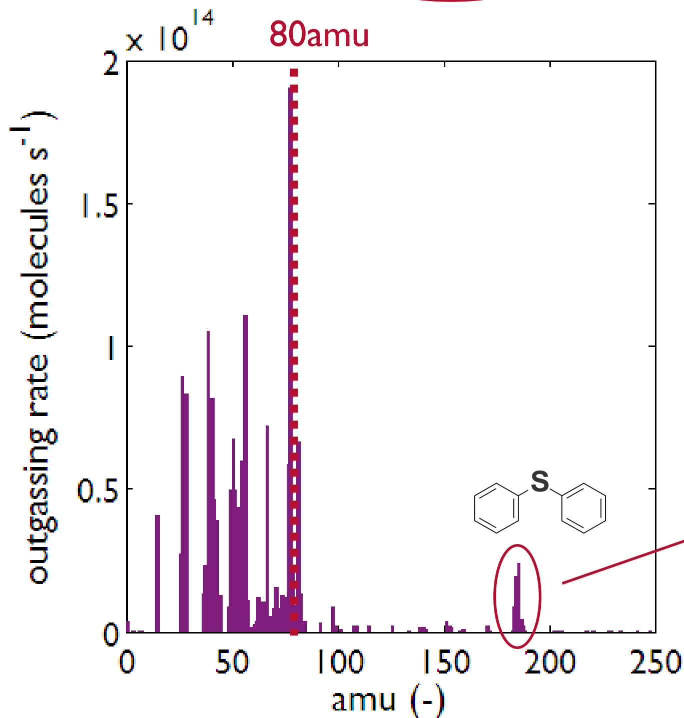
SIMPLE RGA APPROACH TO QUANTIFY THE CONTAMINATION RELATED OUTGASSING



Non-contaminating outgassing

Contaminating outgassing



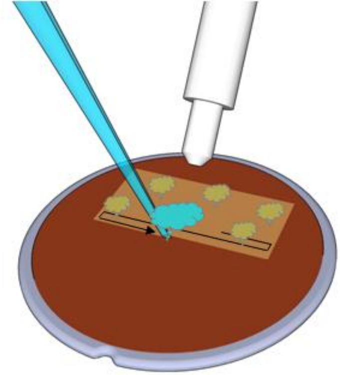
Total cleanable CG rate might be proportional to this outgassing rate :

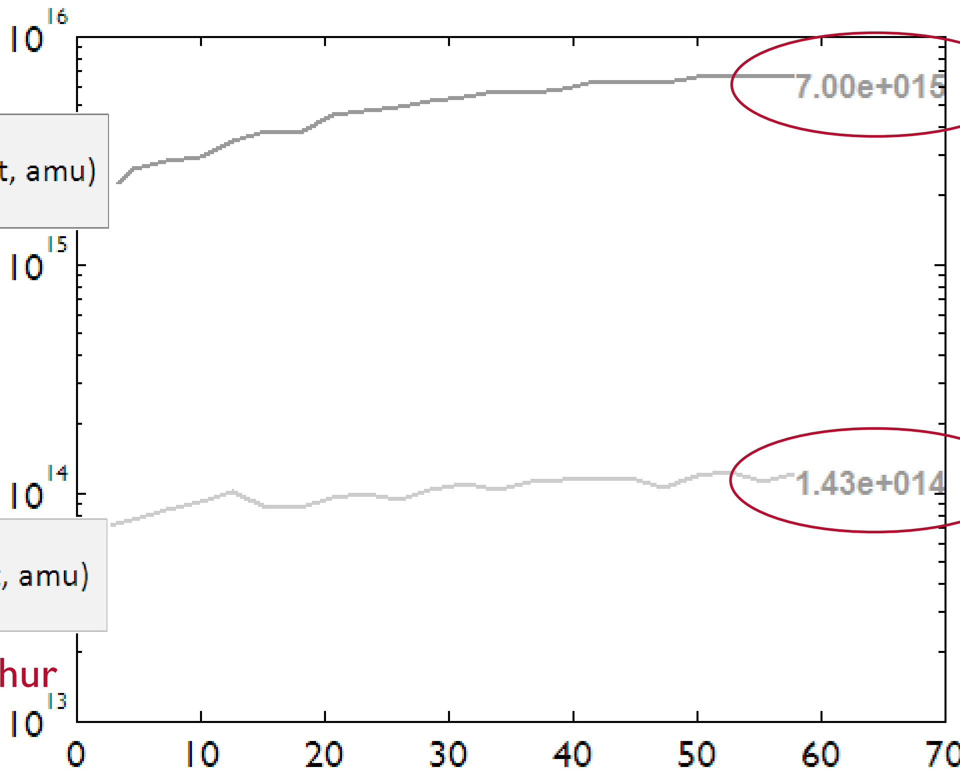
$$\sum_{amu=80}^{250} (amu)^{1/3} \cdot outgas(t, amu)$$

Non-cleanable sulfur contamination rate might be related to this outgassing rate :

$$\sum_{amu=183}^{187} (amu)^{1/3} \cdot outgas(t, amu)$$

Simple RGA approach to quantify the contamination related outgassing





$$\sum_{amu=80}^{250} (amu)^{1/3} \cdot outgas\,(t, amu)$$

'cleanable CG outgassing rate'

$$\sum_{amu=183}^{187} (amu)^{1/3} \cdot outgas\,(t, amu)$$

'non-cleanable sulphur outgassing rate'

'cleanable CG outgassing'

$$\int_{t=0}^{1hr} \sum_{amu=80}^{250} (amu)^{1/3} \cdot outgas\,(t, amu) \cdot dt$$

'non-cleanable sulphur outgassing'

$$\int_{t=0}^{1hr} \sum_{amu=183}^{187} (amu)^{1/3} \cdot outgas\,(t, amu) \cdot dt$$

Integration of this outgassing rate is done over the time of evaluation (1hr); Outgassing rate is increasing due to the 'post-exposure' outgassing.

Complex RGA information can be condensed in 2 parameters. Do they correlate with NXE qualification results ?

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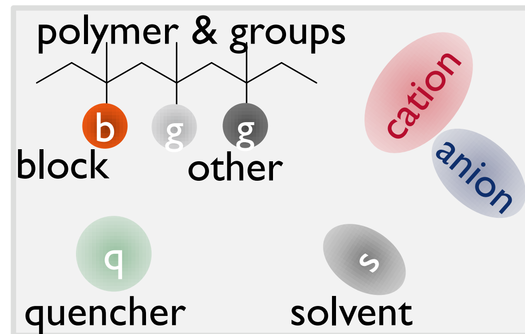
Correlation of RGA and NXE for a large resist family

In collaboration with JSR a DOE was done with 12 model resist with major chemical changes :

Different PAG chemistry and mixtures of PAGs
Different protection groups (low and high activation energy) and mixing the groups in different ratios



Changes are much more than in earlier family definition.

I. Pollentier et al., Proc. of SPIE vol. 7972 (2011)

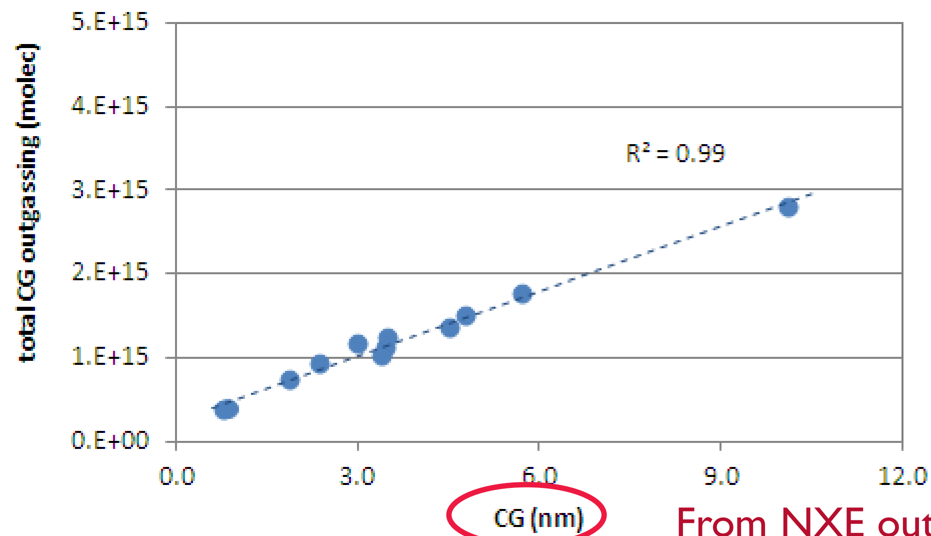
Correlation of RGA and NXE for a large resist family

Different PAG chemistry and mixtures of PAGs
Different protection groups (low and high activation energy) and mixing the groups in different ratios

Very good correlation is found !!!
Preliminary further tests show that model even works for adding UL or TC's !!!

'cleanable CG outgassing'

$$\int_{t=0}^{1hr} \sum_{amu=80}^{250} (amu)^{1/3} \cdot outgas(t, amu) \cdot dt$$



From NXE outgassing WS test !

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Correlation of RGA and NXE for a large resist family

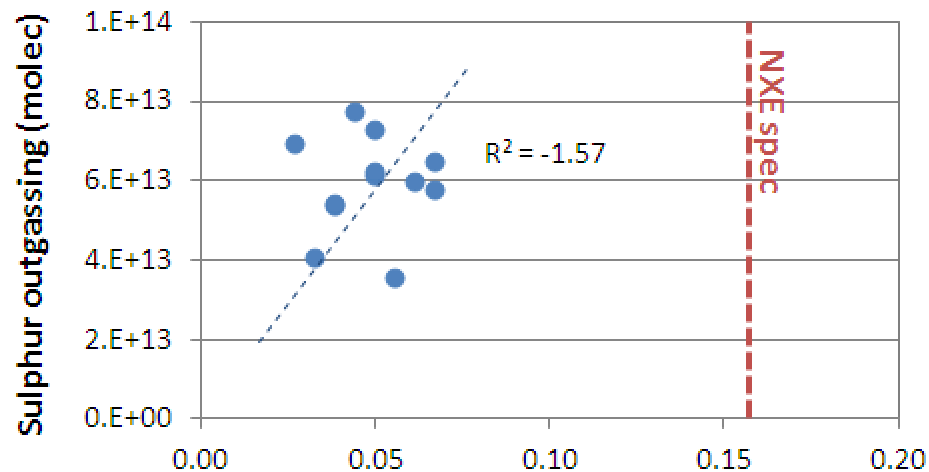
Poor correlation (possibly due to the very long H-cleaning time for some samples), but all well below the NXE-spec.

Other test-case gives better correlation, see Symposium presentation

Different PAG chemistry and mixtures of PAGs
Different protection groups (low and high activation energy) and mixing the groups in different ratios

non-cleanable sulphur contamination ~

$$\int_{t=0}^{1\,hr} \sum_{amu=183}^{187} (amu)^{1/3} \cdot outgas(t, amu) \cdot dt$$



From NXE outgassing WS test !

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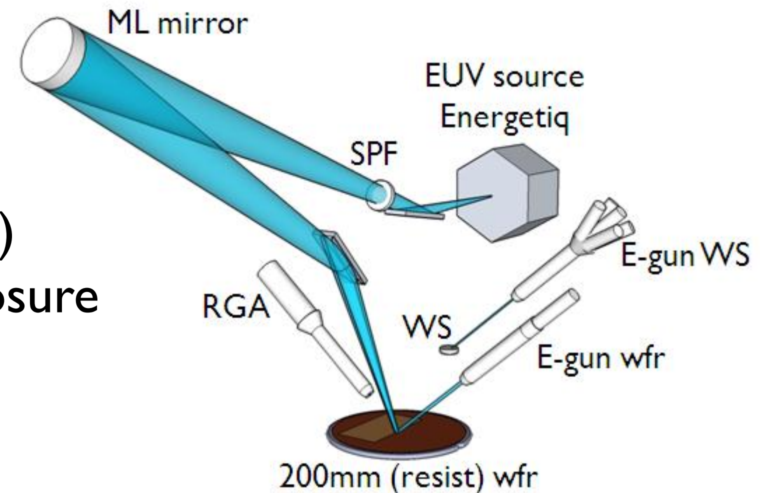
EUV vs. Egun exposure on wafer

Imec set-up is equipped with Egun for resist exposure, therefore CG can be compared between EUV vs. Egun exposure

Differences are observed :

- Over-all Egun gives less (cleanable) contamination than EUV wfr exposure
- Resist dependency



It is planned to investigate further the differences between EUV and E-gun exposure, using again the RGA as intermediate step to detect any differences in dynamic outgassing and composition.

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In the early experience of NXE resist outgas qualification cleanable contamination (chemistry, dose) seems more critical than non-cleanable contamination (mainly sulphur).

A simple RGA method is proposed based on weighted contribution of outgassing for cleanable and non-cleanable contamination.

This model lines up very well for cleanable contamination (R^2 up to 99% !) for a wide range of materials, which should contribute to faster learning and testing.

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