IEUVI Optics Contamination / Lifetime TWG Meeting
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Photoresist Outgassing for EUV HVM Exposure Tool by Canon & Nikon

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Thanks to Colleagues

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Outline

1. Parameters and their values for Outgassing Rate (OGR) Estimation
2. Estimating Upper-limit of Photoresist Outgassing
3. Target of Photoresist Outgassing Rate
4. Dependence of Outgassing Molecules to Carbon Deposition
5. Call for Collaboration
6. Summary

1. Calculating Outgassing Rate

Parameters

Residual CxHy Pressure (Pc)	1×10^{-7} Pa
Effective Evacuation Speed (S)	2.8 m^3/s
Effective Irradiation Rate*1 (Θ)	50%
Incursion Ratio*2 (Φ)	90%
Resist Outgas Fractional Ratio*3 (Ψ)	X%

*1: Ratio of (total light-on time)/(total time)
*2: Ratio of (injected to PO)/(all of outgas)
*3: Ratio of (residual gas attributed to resist)/(all of residual gas)

Outgassing Molecular Mass >45 amu

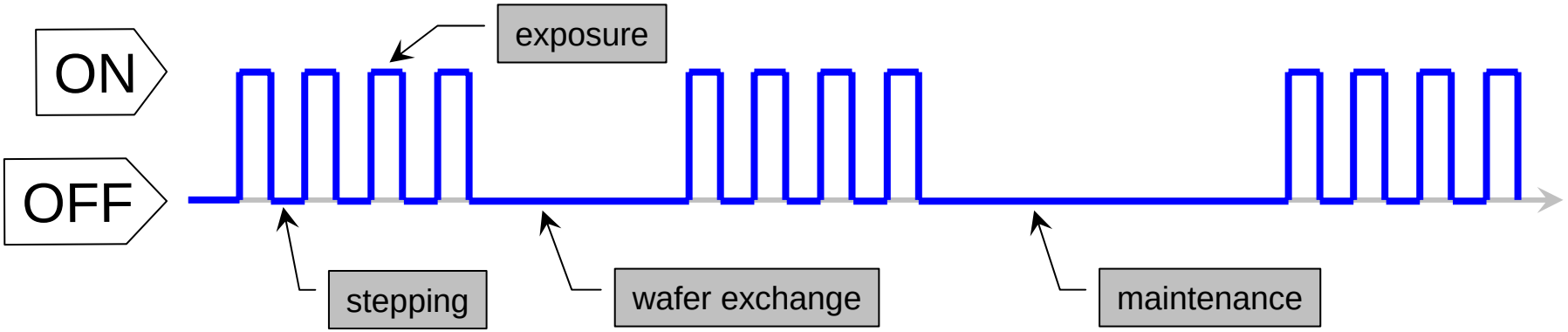
Incident EUV Power on Wafer 0.6 W/cm^2 (180W@IF)

Outgassing Rate = Pc X S / Θ / Φ X Ψ

Canon Nikon

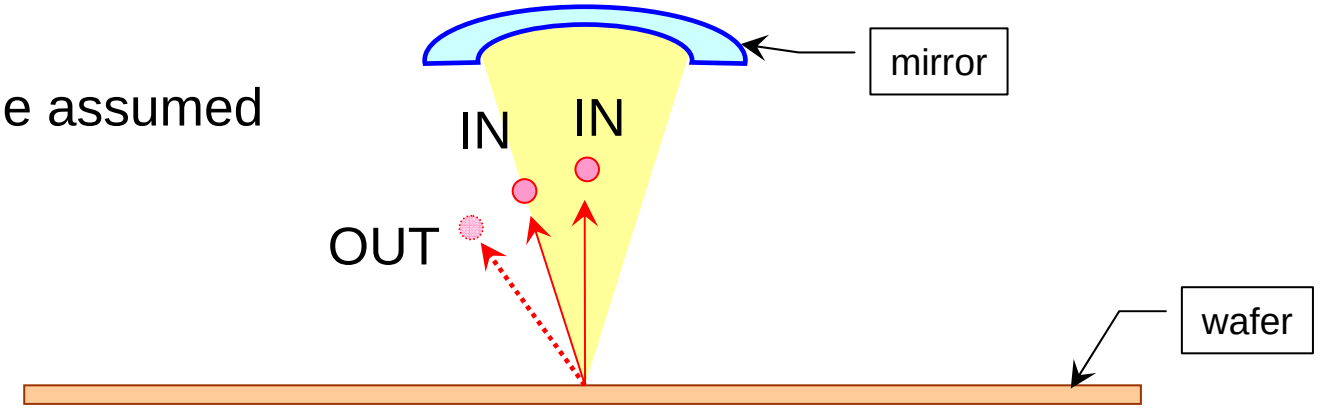
1. Explanations for Parameters

Effective Irradiation Rate = Σ(light ON time)/(total time)



Incursion Ratio = Σ(# of IN molecules)/(# of all molecules)

Cosine rule assumed



2. Estimating Upper-limit of Outgassing Rate

To achieve 1E–7 Pa, upper-limit is derived assuming

Resist Outgas Fractional Ratio[*3] (Ψu) 100%.

Extreme condition for upper-limit estimation

Note that all of residual gas in light path is attributed to resist outgassing and no outgassing from tool itself is supposed in this case,

$$\text{CxHy Outgassing Rate} = Pc \times S / \Theta / \Phi \times \Psi u$$
$$= 3\times10^{14}\ \text{molecules}\ cm^{-2}\ s^{-1}$$

Estimated Upper-limit

Using a resist with >3E14 outgassing, CxHy pressure target, 1E–7 Pa, cannot be achievable.

3. Target of Photoresist Outgassing Rate

We suppose

Resist Outgas Fractional Ratio[*3] (Ψa)　10%,

since outgassing from tool itself cannot be negligible.

Then, the target can be as follows.

CxHy Outgassing Rate = Pc X S / Θ / Φ X Ψa

$= 3 \times 10^{13}$ molecules cm^{-2} s^{-1}

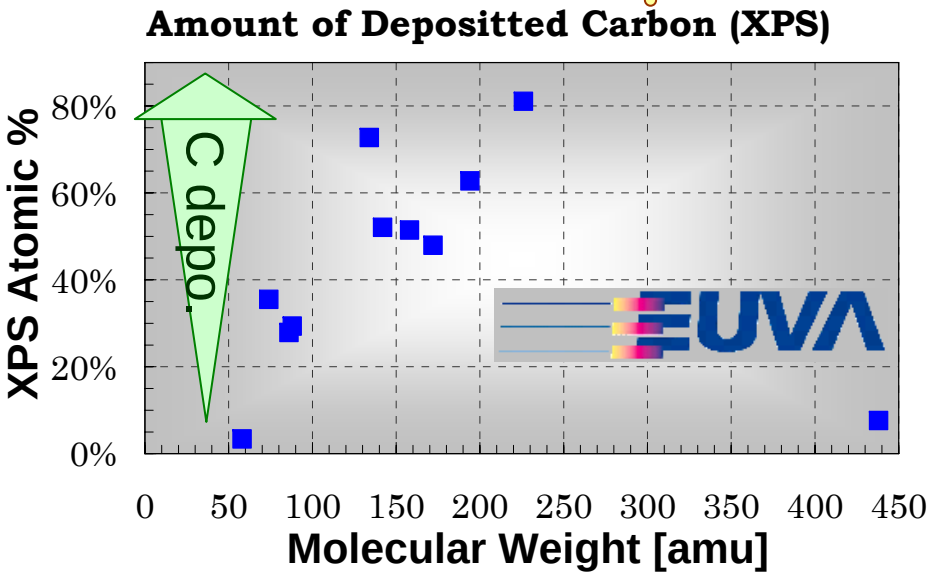
Resist Outgassing Target

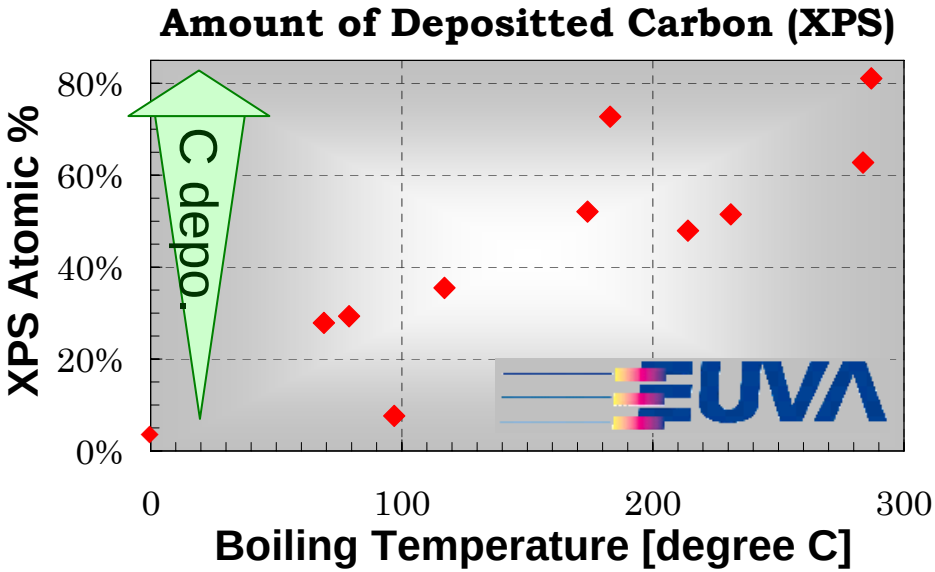
4. Dependence on Organic Gas Species

Molecular Weight (MW)

Presented in Barcelona, 2006

Boiling Temperature (BT)





In general, heavier and/or higher boiling temperature (BT) molecules are much effective to carbon deposition. Note that their adsorption efficiency is rather higher.

Not only outgassing rate but also indicators of carbon deposition rate, *e.g.* MW and BT, are considered to be essential.

5. Call for Collaboration

Actual carbon deposition rate by resist outgas is uncertain because abundance, adsorption and conversion capability of outgassing species are unclear. Collaboration to study and to share the resist outgassing information is crucial.

Call for Collaborative Study

Further study about the following is necessary.

- Identification and quantification of outgassing species, *and/or* clarification of "typical" mass spectrum
- Adsorption and carbon film conversion efficiency of outgassing species

Collaborative study about resist outgassing is necessary.

Summary

1. Canon and Nikon collaborated and agreed with the joint proposal for the resist outgassing.
2. There is an upper-limit of outgassing rate under ordinary vacuum condition.
3. Under the HVM condition, the derived target rate is
   3×10^{13} molecules cm^{-2} s^{-1}
   assuming hydrocarbon outgassing.
4. Our experimental results suggests that heavier and/or higher BT molecules affect much to carbon deposition generally. Therefore, we have to pay attention to not only outgassing rate but also indicators of carbon deposition rate, *e.g.* MW and BT.
5. For the contamination mitigation, further collaborative data accumulation about resist outgassing is necessary, especially identification and quantification, and adsorption and carbon conversion capability of outgassing species.

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