

Comments on Resist Outgas Measurements to remove the confusion in outgassing discussion

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Background - Confusion in outgas round robin -

- There is huge discrepancy in outgas speed data reported to resist TWG !! It is beyond the experimental error. It should be caused by misunderstanding.

Organaization	molecules/cm2	molecules/cm2/s
Intel/UW	4.37E+11	7.28E+09
ASET	----	2.2 E+14

- There is fatal lack of information in ASML's requirement.

- There are two type method in outgas metrology.

1. Accumulation methods (U. Wisconsin)

molecules/cm² at E_{size}

2. Pressure rise method (Many organization)

molecules/cm²/s at I_{exposure}

Different physical quantities were measured, however conversion method between each values ware not established.

Resist Outgassing Results

- Five groups reported values, the other two will report at February 2006 meeting
- Outgassing rates varied between E+11 and E+13 molecules/cm²-sec, a huge variation in results!
- Different methods were used, group discussed ways to better compare results
- Much discussion of ASML specs and what is really important, hydrocarbons or heteroatoms, low or high molecular weights?

Lack of information in ASML requirement

ASML's Requirement

cf) IEUVI resist TWG meeting in Miyazaki

H ₂ O	4.7E15	molecules·cm ⁻² ·s ⁻¹
CxHy	4.7E13	
F/Cl	4.7E11	

Based on 1 % budget of Back Ground gas in Exposure Tool

- There is a lack of information of **EUV intensity on wafer** in this specification.
- We cannot calculate the outgassign rate corresponding to ASML requirement from experimental data without the disclosure of intensity in production tool.

Estimation of EUV intensity on wafer in production tool

Method-1 : from the source power of **115 W@IF**。

Total reflectivity loss of by 12 multilayer mirror(R=68%) = 0.01

Reflectivity loss by mask (65%)= 0.65

Other loss (50%: not sure): 0.5 → Total: 0.35 %

EUV power leaching onto wafer is **0.4 W**. IF the exposure area is assumed to be 0.5cm², EUV intensity on wafer is **0.8 W/cm²**.

Method-2: from throughput of **100 WpH** and resist sensitivity of **5mJ/cm²**

Exposure area= $\pi \times (15\text{cm})^2 \times 80\%$ (effective area ratio)=565 cm²

Exposure time=3600s/100x40%(overhead correction)=14.4 s

$$\text{Power} = \frac{5 \text{ mJ/cm}^2}{14.4 \text{ s}} \times 565 \text{ cm}^2 = \mathbf{0.2 \text{ W}}$$

$$\text{EUV intensity} = 0.2\text{W}/0.5 \text{ cm}^2 = \mathbf{0.4 \text{ W/cm}^2}$$

Though there are twice discrepancy, It is not so bad..

Temporary, we adopt **0.2 W** for power and **0.4 W/cm²** for intensity.

How to convert from molecules/cm² to molecules/cm²/s

If the outgassing amount of **M molecules/cm²** is obtained using resist of **ε J/cm²** (Esize), outgassing amount in 1s can be calculated as follows

$$\begin{aligned} \text{Exposure time for Esize in EUV intensity of } I_{\text{euV}} \text{ W/cm}^2 \\ = \varepsilon \text{ (J/cm}^2\text{)} / I_{\text{euV}} \text{ (W/cm}^2\text{)} = \varepsilon / I_{\text{euV}} \text{ (s)} \end{aligned}$$

overhead correction factor (duty ratio) = α

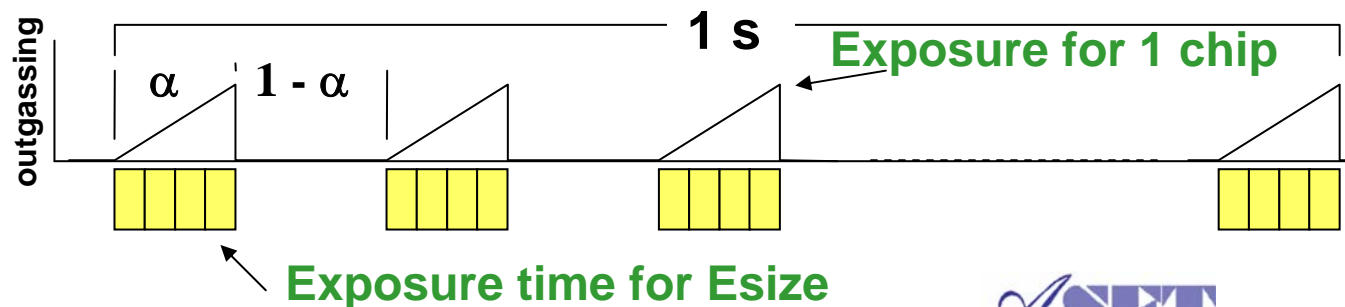
$$\text{number of irradiation for Esize exposure} = \alpha I_{\text{euV}} \text{ (s)} / \varepsilon$$

$$\text{Outgassing amount in 1 s} = M \times \alpha I_{\text{euV}} \text{ (s)} / \varepsilon$$

If $\alpha = 0.4$, $\varepsilon = 5.5 \text{ mJ/cm}^2$, and $I_{\text{euV}} = 0.4 \text{ W/cm}^2$ is assumed,

$$\text{conversion factor: } \alpha I_{\text{euV}} \text{ (s)} / \varepsilon = 30$$

So, 10^{12} molecules/cm² in accumulation method corresponds to the outgassing rate of 3×10^{13} molecules/cm²



Comment on Intel/Wisconsin Experimental Data

cf) IEUVI resist TWG meeting in Miyazaki

Outgassing from Sematech Round Robin Resist Exposure at UW & GC/MS at Intel

Sample LL-TF-99246

R.T. (min)	detected compound	Ion (m/z)	outgassing conc (molecules/cm ²)	outgassing rate (molecules/cm ² sec) Assume 60 sec exp
12.051	tert-Butylbenzene	119,91,134	4.04E+11	6.74E+09
17.228	Methylstyrene	118	3.22E+10	5.37E+08
Total			4.37E+11	7.28E+09

- Outgassing conc of 4.37E+11 molecules/cm² corresponds to outgassing rate of **1.3E+13** molecules/cm² in my calculation.
- This is close to ASML specification for hydrocarbon outgassing rate of **4.7E+13**.
- Discrepancy with ASET Data (**2.2 E+14**) is reduced to one order of magnitude. It is still large, but seems likely because experimental method is quite different

Conclusion

- There is huge discrepancy in outgas speed data reported to in resist TWG !! It causes confusion in outgassing discussion.
- There is fatal lack of information on the **EUUV intensity** in production tool in ASML's requirement.
- EUUV power and intensity on wafer in production tool were estimated to be about **0.2 W** and **0.4 W/cm²** respectively.
(Kim-san should be confirm this value to ASML key person.)
- Conversion constant from outgassing conc (molecules/cm²) to outgassing rate(molecules/cm²s) is estimated about 30 based on the estimated intensity on wafer.
- By using the estimated conversion constant, discrepancy between Intel and AET Data was reduced to within one order of magnitude.