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

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This work was supported by NEDO.

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/cm^2 at E_{size}
  2. **Pressure rise method (Many organization)**
     molecules/cm^2/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/cm^2-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_2O	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 0.5cm^2, EUV intensity on wafer is 0.8 W/cm^2.

Method-2: from throughput of 100 WpH and resist sensitivity of 5mJ/cm^2

Exposure area= π x(15cm)^2 x 80%(effective area ratio）=565 cm^2
Exposure time=3600s/100x40%(overhead correction）=14.4 s

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

EUV intensity =0.2W/0.5 cm2 = 0.4 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.

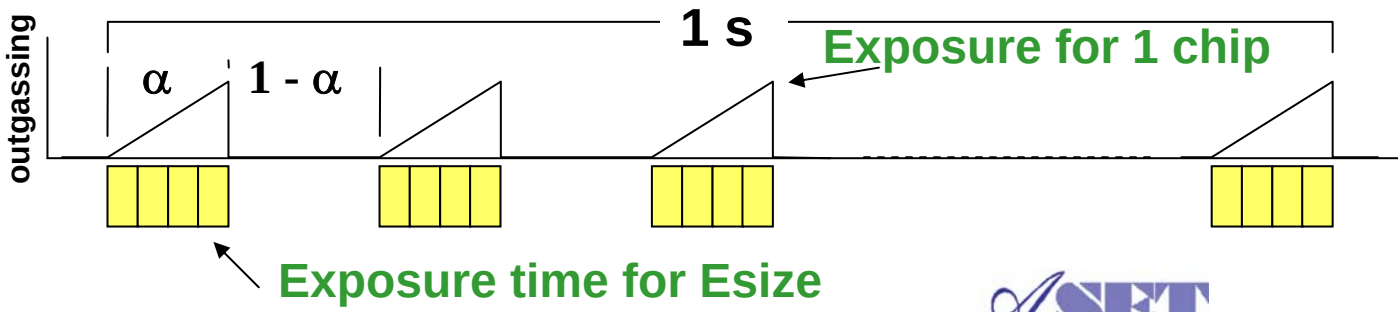
How to convert from molecules/cm^2 to molecules/cm^2/s

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

Exposure time for Esize in EUV intensity of I_{euv} W/cm^2
= ε (J/cm2) / I_{euv} (W/cm^2) = ε / I_{euv} (s)
overhead correction factor (duty ratio) = α
number of irradiation for Esize exposure = α I_{euv} (s) / ε
Outgassing amount in 1 s = M × α I_{euv} (s) / ε

If α =0.4, ε = 5.5 mJ /cm^2, and I_{euv} =0.4 W/cm^2 is assumed,
conversion factor: α I_{euv}(s) / ε = 30

So, 10^{12} molecules/cm^2 in accumulation method corresponds to the outgassing rate of 3 x 10^{13} molecules/cm^2



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/cm2)	outgassing rate (molecules/cm2sec) 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 outgasing 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 EUV intensity in production tool in ASML's requirement.
- EUV power and intensity on wafer in productin 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 constan, discrepancy between Intel and AET Data was reduced to within one order of magnitude.