

EUV Resist Outgassing:

What we know and what we don't know

IEUVI Contamination and Optics TWG Meeting

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SEMATECH

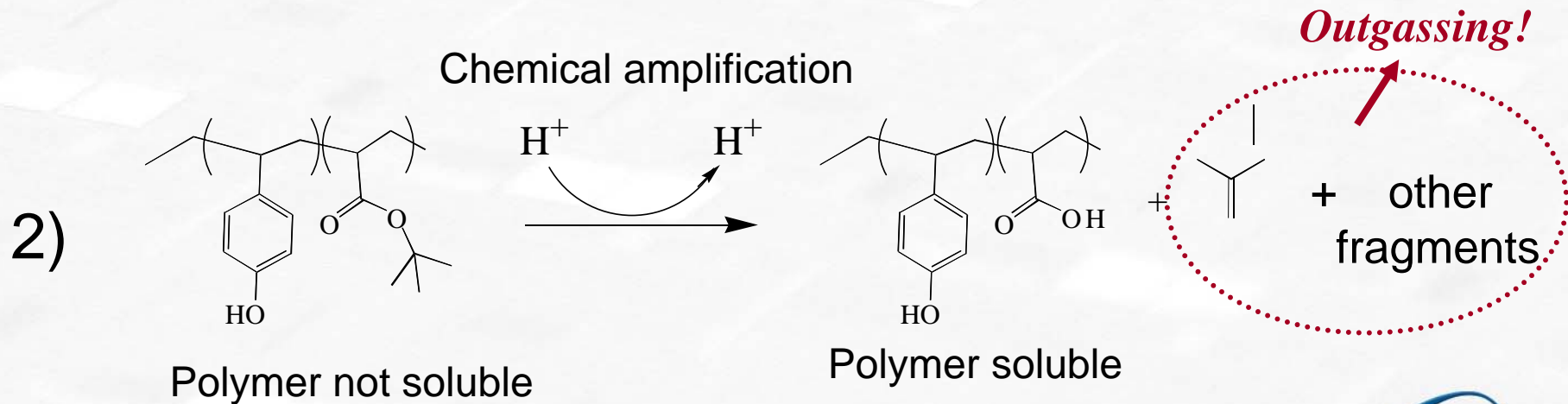
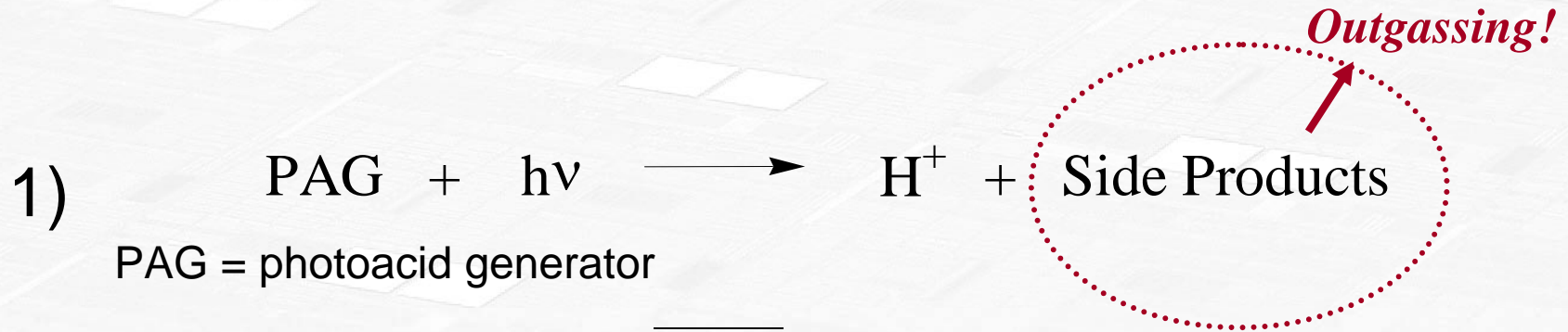
March 2, 2005



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EUV Resist Basics

- Resist chemical reactions occur with light and heat.
- Outgassing happens.



Published Resist Outgassing Data, Examples

1. Chemically amplified (CA) resist outgassed $\sim 10^{12}$ molecules/cm²-sec
 - Quartz crystal microbalance and mass spec
 - Isobutene and CO₂ from acid catalyzed deprotection
 - SO, CF₂, CHF, and SO₂ from PAG decomposition
2. Several non-CA and CA resists were compared using mass spec
 - ZEP 520 partial pressure of hydrocarbons mass > 44, 1×10^{-6} Pa (10^{-8} mbar, 8×10^{-9} torr)
 - CA resist $10^{-9} - 10^{-8}$ Pa ($10^{-11} - 10^{-10}$ mbar, $8 \times 10^{-12} - 8 \times 10^{-13}$ torr)

1) Chauhan and Nealey, J. Vac. Sci. Technol. B 18(6), 2000.

2) Watanabe, et al., J. Photo. Sci. and Techno., 14(4), 2001.



Published Resist Outgassing Data, Examples

3. Resist outgassing measured and adhesion to Mo/Si and Si substrate studied
 - Outgassing measured by mass spec
 - ZEP520 > CA (ESCAP type)
 - Main components CO₂ and hydrocarbons
 - TOF-SIMS data of substrate showed no correlation to mass spec data

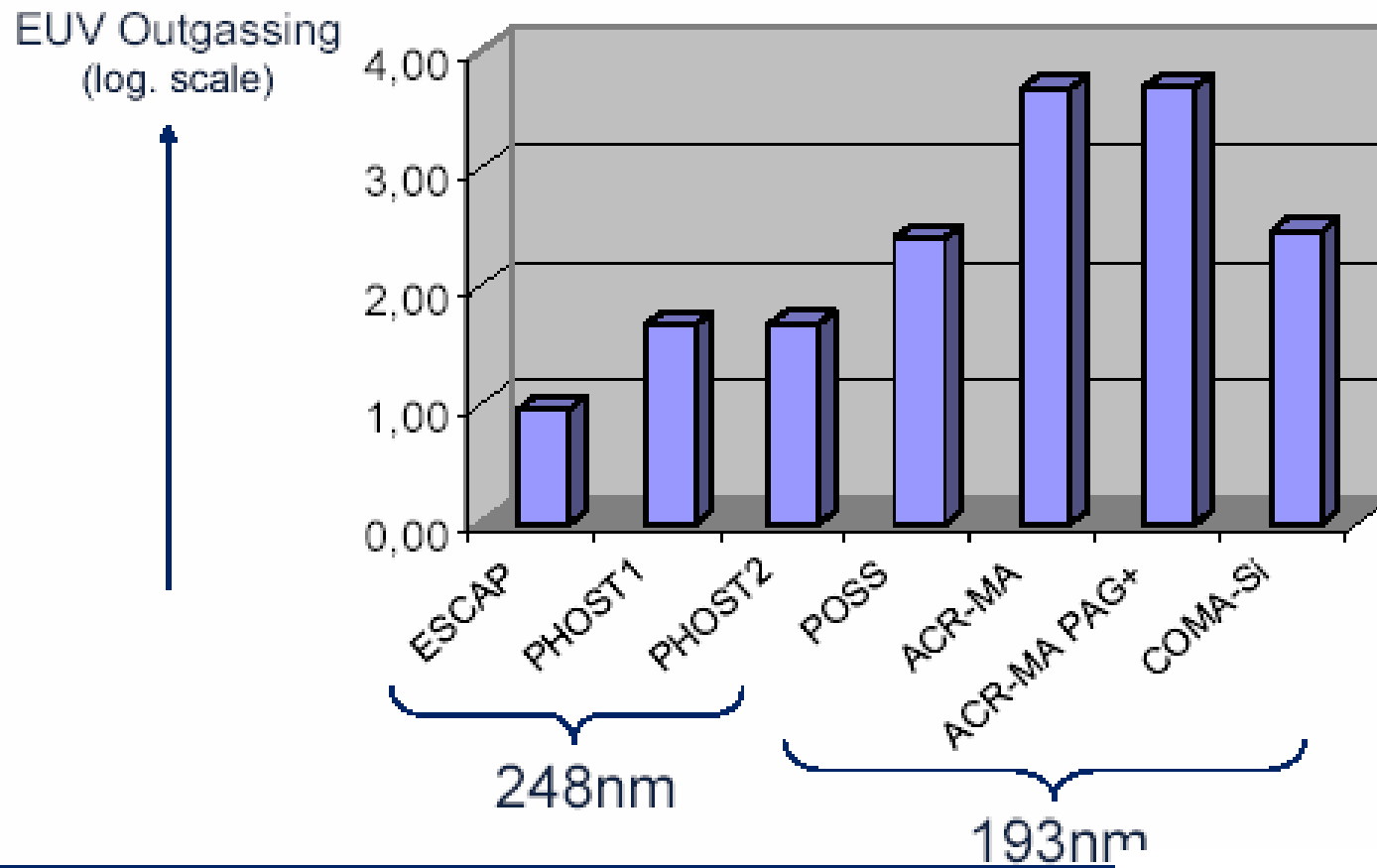
4. EXCITE compared several resist platforms
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3) Irie, et al., J. of Photo. Sci. Technol., 14(4), 2001.

4) Domke, IEUVI Resis TWG, Nov. 2005.



Comparison of total outgassing



Top Three Issues for Resist TWG Cooperation (July, 2004)

- 1. What is a safe level of resist outgassing?**
 - Work together to determine specifications, include tool and resist suppliers
- 2. Understanding the resolution limits of chemically amplified resists**
 - Provide enough tool time for cycles of learning
- 3. How to optimize photospeed, LWR, shot noise, resolution?**
 - Design experiments to investigate these parameters



Top Three Issues for TWG Cooperation (Nov. 2004 meeting)

1. What is a safe level of resist outgassing?

- ASML's targets for Alpha tool* (1% of total outgassing budget allowed for resist)

H ₂ O	4.7E15 (molecules/cm ² -sec)
C _x H _y (integr. > 44 AMU)	4.7E13
F/Cl	4.7E14
S/P	4.7E11
Si	4.7E9

- Nikon's specifications for total outgassing*:

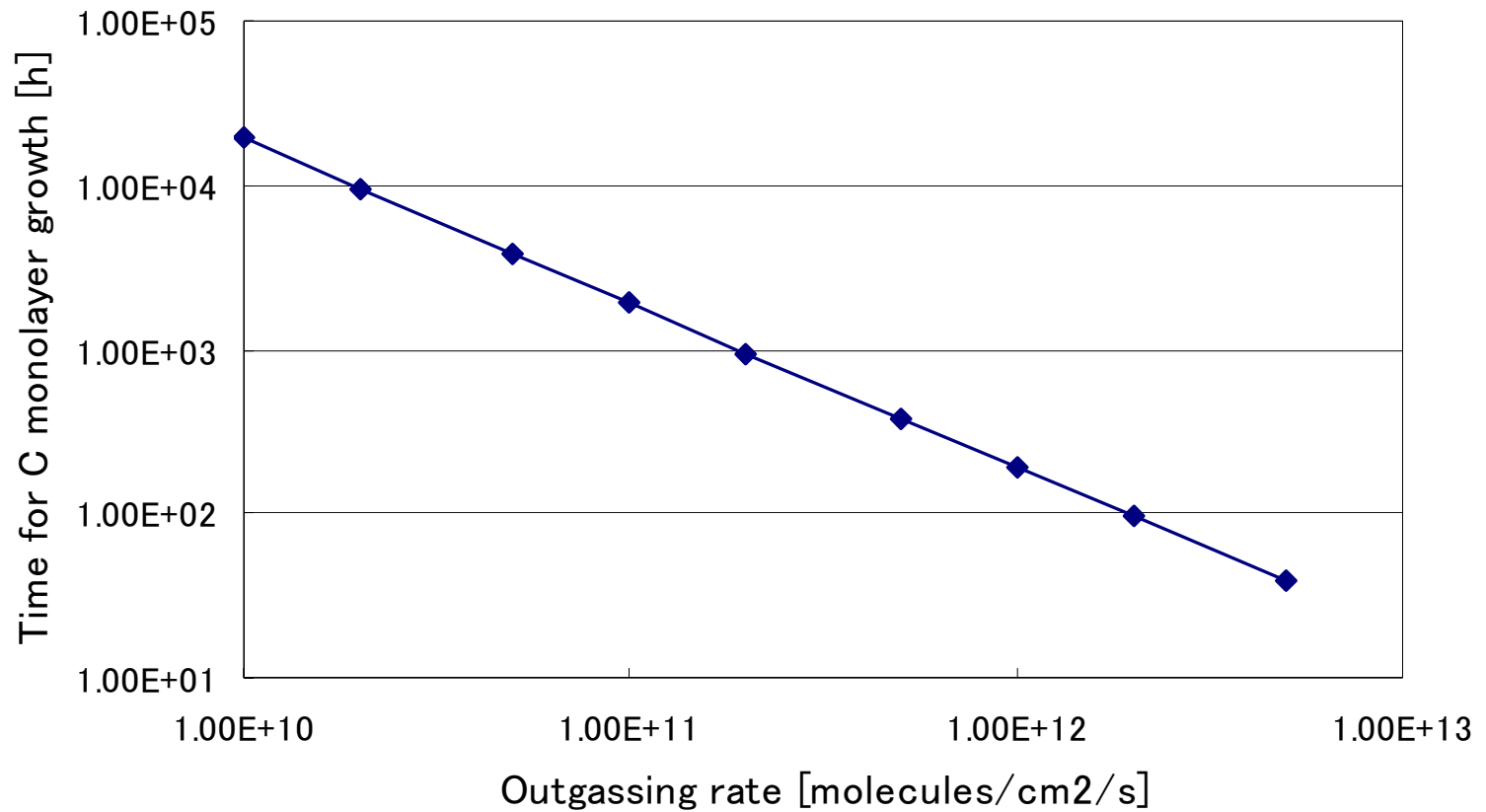
2005	2E11 (molecules/cm ² -sec)
2007	5E10
2009	1E10

*Data courtesy of ASML and Nikon Corporations, IEUVI Resist TWG, Nov. 2004.



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Contamination of mirrors due to resist outgassing*



5 monolayers correspond to 1% reflectivity loss of multilayer-coated mirror.

*Data courtesy of Nikon Corporation, IEUVI Resist TWG, Nov. 2004.



Observations from Tool Suppliers

- ASML is budgeting 1% of their outgassing to resist
- Nikon considered outgassing to be “yellow” on concern scale
- Nikon presented tighter outgassing limits (10^{11} for 2005)
- Worst contaminant is silicon (tightest spec)

Top Three Issues for TWG Cooperation (Nov. 2004 meeting)

1. What is a safe level of resist outgassing?

- Group decided to use the units of molecules/cm²-sec
- Will start with Intel's limit of total outgassing 6E13 molecules/cm² (need to convert to rate)
- At least 7 research groups working on resist outgassing
- Resist TWG working together on specifications and areas of cooperation

*Data courtesy of ASML Corporation, IEUVI Resist TWG, Nov. 2004.



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What we don't know:

1. Which resist outgassing method is the best predictor?
2. Does the outgassing data collected from synchrotron sources provide predictive data for production tools?
3. What matters? Resist thickness, time dependence of outgassing
4. What's important, total outgassing values or specific species?
5. Is SO₂ important? CO₂?

