



# ASML

## New method for resist outgassing qualification

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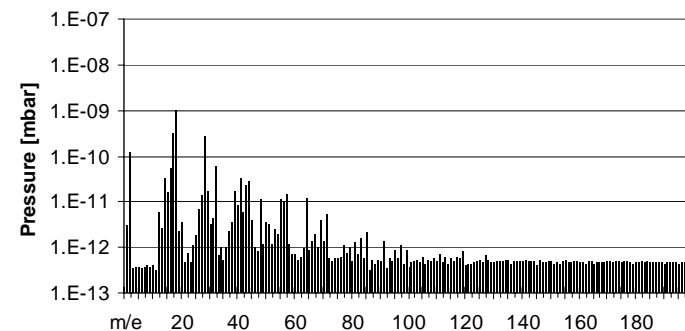
# Current method

- Current resist outgassing specifications:
  - $\text{H}_2\text{O}$   $5\text{E}+15 \text{ mlc cm}^{-2} \text{ s}^{-1}$
  - $\text{C}_x\text{H}_y \Sigma[\text{m}45\text{-m}100]$   $5\text{E}+13 \text{ mlc cm}^{-2} \text{ s}^{-1}$
  - $\Sigma [\text{F}, \text{Cl}, \text{I}]$   $5\text{E}+14 \text{ mlc cm}^{-2} \text{ s}^{-1}$
  - $\Sigma [\text{S}, \text{P}]$   $5\text{E}+11 \text{ mlc cm}^{-2} \text{ s}^{-1}$
  - $\Sigma \text{Si}$   $5\text{E}+9 \text{ mlc cm}^{-2} \text{ s}^{-1}$

Method: RGA measurement during resist exposure

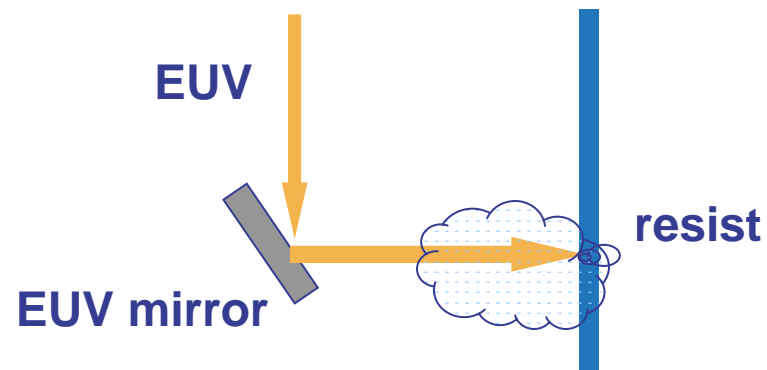
*Drawback: no direct relation between RGA spectrum and optics contamination*

*Example*



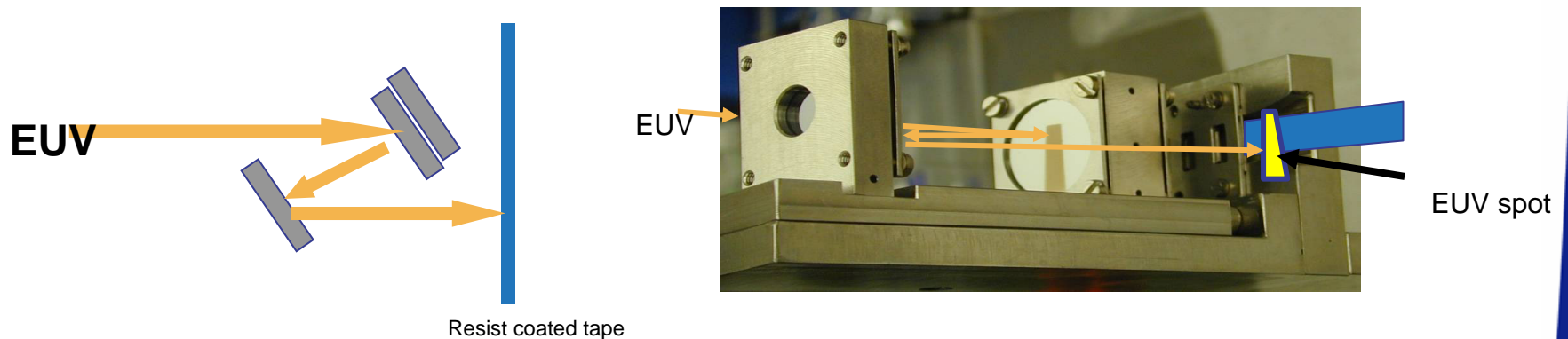
# Novel method

- Expose simultaneous mirror and resist
- Direct relation between euv induced outgassing of resist and mirror degradation



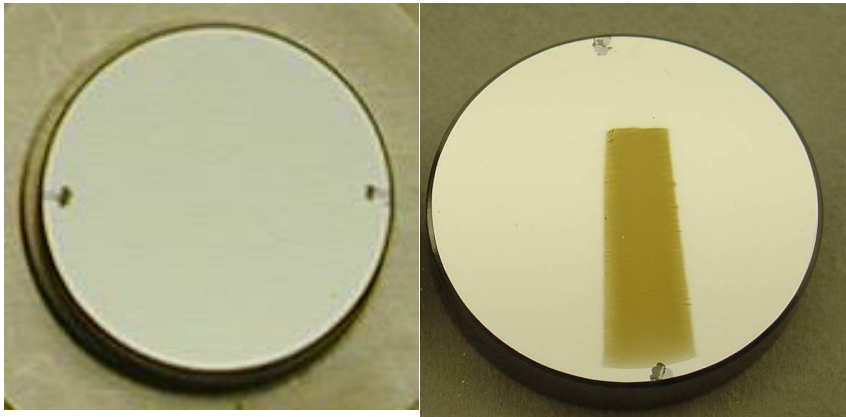
# Experimental results: MET-2D → setup

- Exposure of large area EUV resist MET2-D at synchrotron at dose to size and intensity corresponding to 10 WPH
- Simultaneously exposure multilayer mirrors to show the contamination effect
- Ex-situ in-band reflectometry of multilayer mirrors to quantify contamination effect
- Applying the AD-tool mirror cleaning to these mirrors

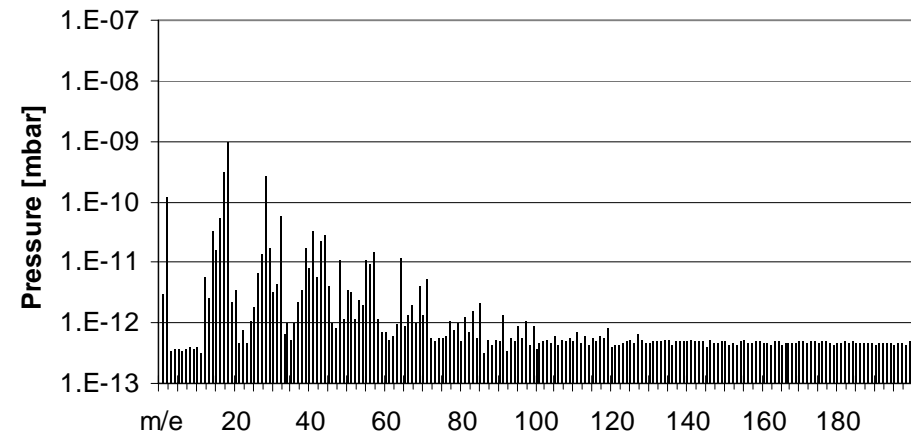


## Experimental results: MET-2D → exp data

- Amount of resist exposed ~ 113 wafers *under accelerated conditions!!* (no resist debris suppression as in ASML ADT)
- EUV induced reflection loss of DR/R = -33%
  - Significant carbon growth in EUV exposed spot
  - No significant carbon growth in areas not exposed to EUV
- Outgassing measured with RGA → just within ASML specification (e.g. SO<sub>2</sub>)

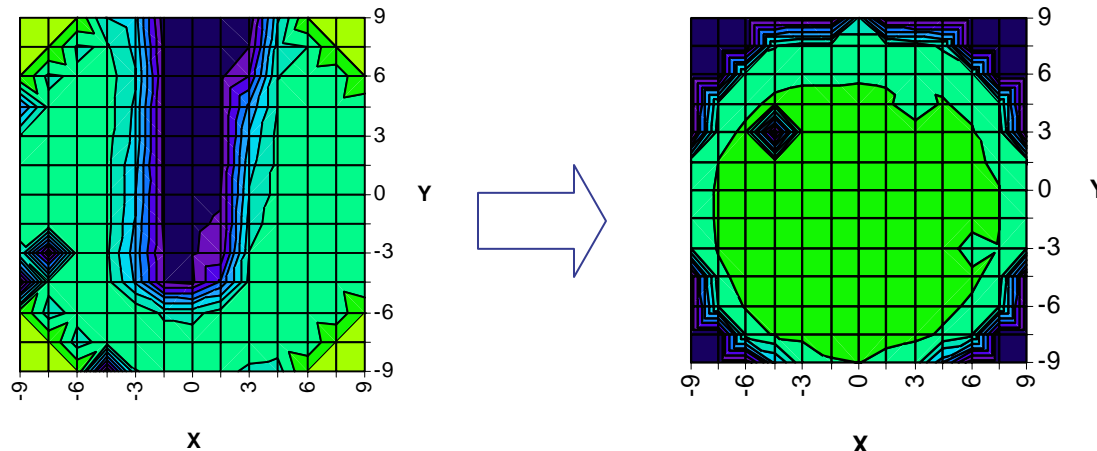


Before and after exposure → DR/R = -33%  
→ Carbon spot mimics EUV beam shape



# Experimental results: MET-2D → cleaning

- Cleaning method: identical to ASML AD tool  
[cleaning = removal of contaminant without degradation of multilayer]



2D reflectivity plots, before (left) and after (right) cleaning

- Reflection completely recovered !
- But what about other resists?.....



# ASML new specification (1/2)

- Expose simultaneous mirror and resist
- EUV source: pulsed source (1-10kHz)

|                       | AD-tool                   | Production tool          |
|-----------------------|---------------------------|--------------------------|
| • Intensity at resist | 60 mW/cm <sup>2</sup>     | 0.5-1 W/cm <sup>2</sup>  |
| • Total dose resist   | dose to clear             | dose to clear            |
| • Intensity at mirror | >0.1–1 mW/cm <sup>2</sup> | >1-10 mW/cm <sup>2</sup> |

Total resist area exposed (wafer Ø300mm)

|              |               |                  |
|--------------|---------------|------------------|
| • LithoTool  | 10.000 wafers | 3.000.000 wafers |
| • Experiment | >1 wafer      | >300 wafers      |

Taken into account: resist debris suppression method



# ASML new specification (2/2)

Expose resist equivalent 1 300mm wafer\*

\* For AD qualification

Measure in-band reflection loss

$\Delta R/R < 2\%$   
PASS

$2\% < \Delta R/R < 30\%$

$\Delta R/R > 30\%$   
FAIL

Clean contamination

$\Delta R/R < 2\%$   
PASS

$\Delta R/R > 2\%$   
FAIL





# Summary

- Current method of resist outgassing: RGA
- Drawback: No direct relation between outgassing products and mirror degradation
- ASML new specification procedure: simultaneous exposure of EUV mirror and resist under realistic conditions
- Experimental conditions and decision tree are specified
- For more detailed questions: do not hesitate to ask us:
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