



New method to qualify resist induced contamination

Anemieke van de Runstraat¹, Anton de Jong¹, Roel Moors², Dirk Ehm³, Bas Wolschrijn^{1*}
¹ TNO Science and Industry, P.O. Box 155 2600 AD Delft, The Netherlands * corresponding author: bas.wolschrijn@tno.nl
² ASML, De Run 1110, Veldhoven, The Netherlands
³ Carl Zeiss SMT-AG, Abt. HL-VT, D-73446 Oberkochen, Germany

Introduction

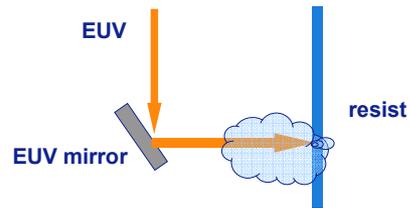
- **Current method:** measure resist outgassing (molecules/cm²) with a RGA during EUV exposure of resist
- **Drawback**
 - RGA spectra difficult to interpret
 - No prediction possible of actual contamination formed on optics in lithography tools
- **New method developed by TNO:** simultaneous exposure of resist and substrates in the same experiment
- **Advantages**
 - ⇒ Contaminate with actual outgassing mixture
 - ⇒ Mimic contamination conditions in tool as close as possible
 - ⇒ Accelerated test easily possible
- **Dedicated apparatus built at TNO to exposed large area resist to qualify EUV resist qualification for ASML/Carl Zeiss**

Current resist outgassing specifications by ASML:

• H ₂ O	5E+15 mlc cm ⁻² s ⁻¹
• CxHy Σ[m45-m100]	5E+13 mlc cm ⁻² s ⁻¹
• Σ [F, Cl, I]	5E+14 mlc cm ⁻² s ⁻¹
• Σ [S, P]	5E+11 mlc cm ⁻² s ⁻¹
• Σ Si	5E+9 mlc cm ⁻² s ⁻¹

Novel method:

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



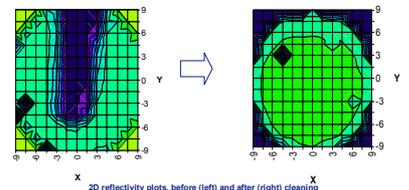
Experimental results: example MET-2D

- Exposure of large area EUV resist MET-2D 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

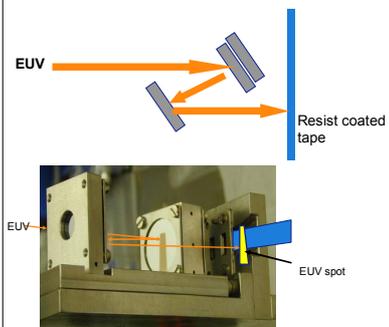
- Amount of resist exposed ~ 113 wafers under accelerated conditions!! (no resist debris suppression as in ASML ADT)
- EUV induced reflection loss of ΔR/R = -33%
 - Significant carbon growth in EUV exposed spot
 - No significant carbon growth in areas not exposed to EUV
- Outgassing measured with RGA → just within ASML specification (e.g. SO₂)

CLEANING

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



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



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

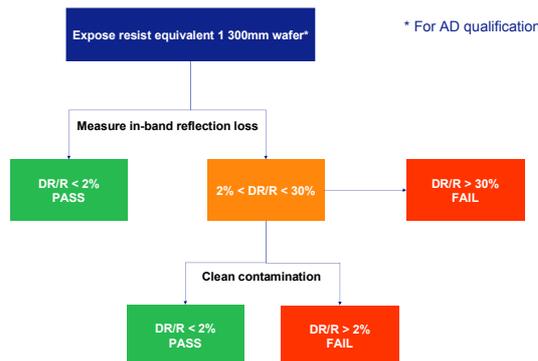
ASML proposed protocol

Summary

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

	AD-tool	Production tool
Intensity at resist	0.6 mW/mm ²	5-10 mW/mm ²
Total dose resist	dose to clear	dose to clear
Intensity at mirror	>0.1-1 mW/cm ²	>1-10 mW/cm ²
Total resist area exposed (wafer Ø300mm)		
LithoTool	10000 wafers	3.000.000 wafers
Experiment	>1 wafer	>300 wafers

Taken into account: resist debris suppression method



- Current method of resist outgassing: RGA
- Drawback: No direct relation between outgassing products and mirror degradation
- ASML proposal: simultaneous exposure of EUV mirror and resist under realistic conditions
- Experimental conditions and decision tree are specified