

SEMATECH Resist Outgas Testing Update



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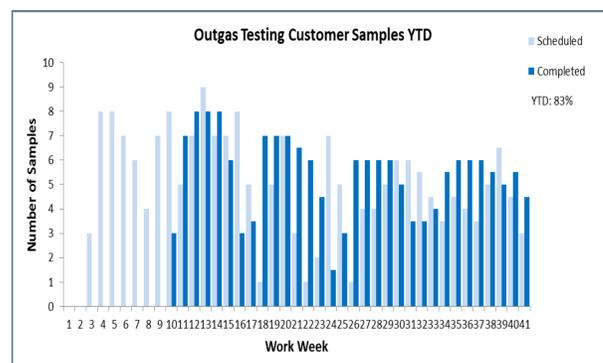
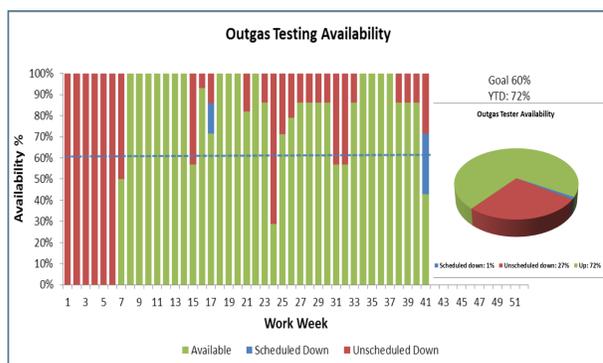
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Abstract

During the last IEUVI resist technical working group (TWG), ASML relaxed the cleanable contamination specification for witness sample based resist outgas test which relieves resist suppliers for the new formulation development. Based on the knowledge of current outgas test results and the need to develop many new formulations, a resist family test would be critical and further stimulate resist development using new materials for the next generation EUV exposure tools by enabling a more efficient way for outgas test. In order to evaluate the feasibility of the family testing concept, SEMATECH initiates a family test experiment and collaborates with one of the resist suppliers to demonstrate the outgas testing results using EUV resists that has shown proven imaging performance. The concept of family resist testing assumes the more photo acid generator (PAG), more protecting units (PU), and more quencher would always lead to a higher outgas, but we have found that this is not always the case. In this paper, resist family definition, experiment steps, and final results for witness sample based resist family test will be discussed.

SEMATECH Outgas Update

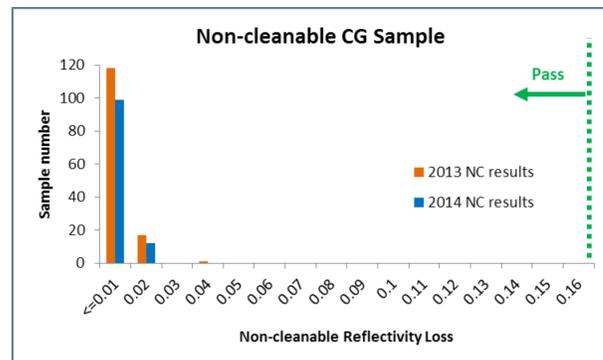
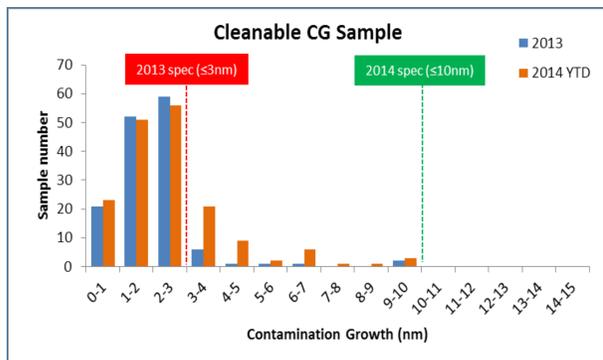
- Overall tool availability in 2013: 52%
- Overall tool availability in 2014 YTD: 72%
- Tool unavailable during WW01–WW07, tool back on tracked



Cleanable contamination from resist outgassing has been relaxed from 3nm to 10nm by ASML

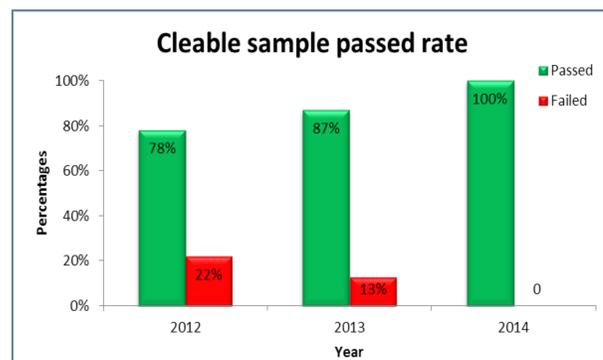
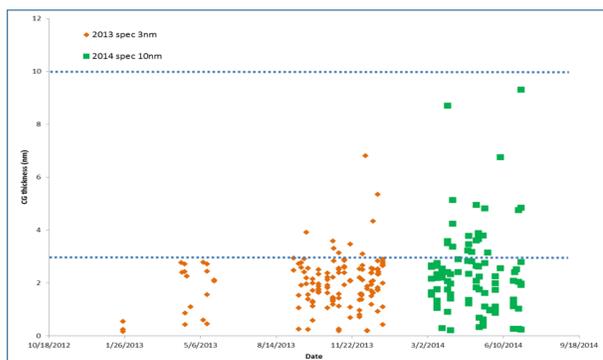
- Customer sample tested in 2013: 164 (EUVT + ROX)
- Customer sample tested in 2014 YTD : 173 (EUVT only)

- 2013 cleanable contamination test failed 3nm spec: 22
- 2014 YTD cleanable contamination test failed 10 nm spec: 0



- More higher outgas materials have been developed in 2014
- Does that helps the EUV resist development?

- We have not seen a failed sample in 2014 after the relaxation



Resist Family Test

Definition

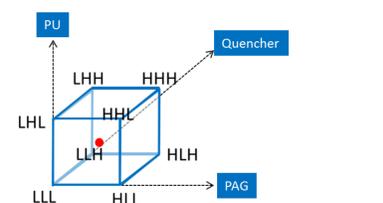
- Resist family is a word used to define a group of chemical amplified resists composed of the same chemical compounds with variable concentration

Objective

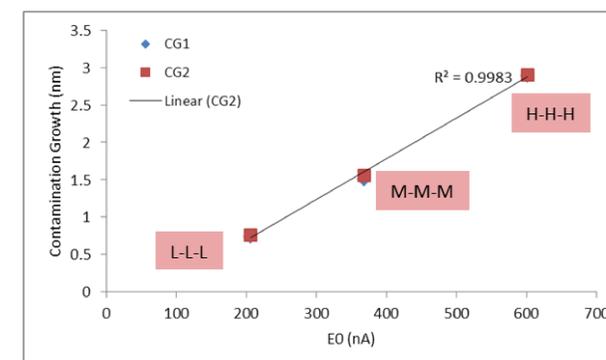
- Avoid unnecessary or duplicated outgas testing to meet the demand for high volume manufacturing

Experimental Description

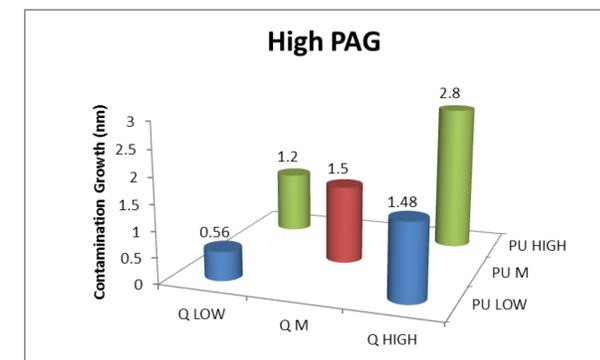
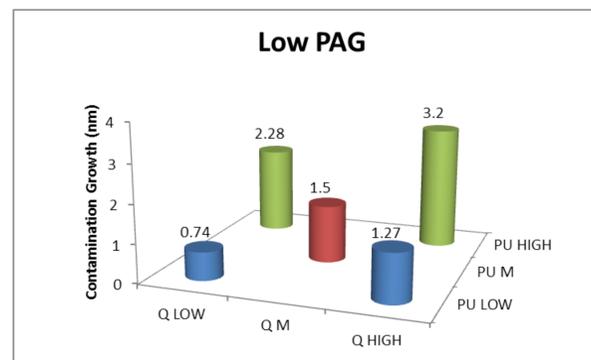
- Goal of this experiment is to determine the highest outgas family resist from a combination of 3 resist components, PAG loading, Protecting Unit, and Quencher.
- Experiment was performed based on an real EUV resist family provided by one of SEMATECH's resist suppliers
- The resist family has demonstrated good imaging performance on both AMET and BMET
- POR resist was measured on a daily basis before running these family resist samples to ensure consistency and accuracy
- All E0 (required dose to print) tests were confirm by coarse and fine contrast curve to determine a proper dose
- All contamination growth (CG) tests were repeated at least once to confirm the test results



- Labels: PAG – PU – Quencher throughout the entire experiment
- Each resist component has high and low concentration
- There was equal amount difference between LLL-MMM-HHH. CG (nm) is perfectly scaled with dose on these samples
- HHH & LHH result in highest outgas

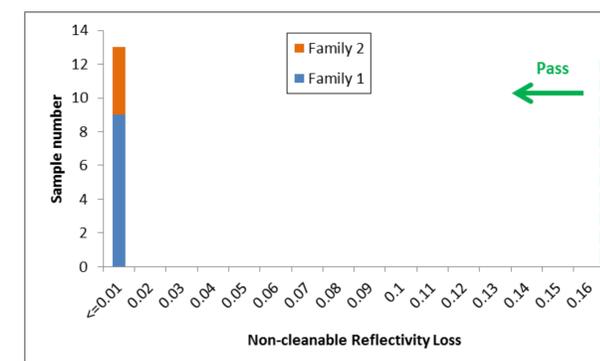
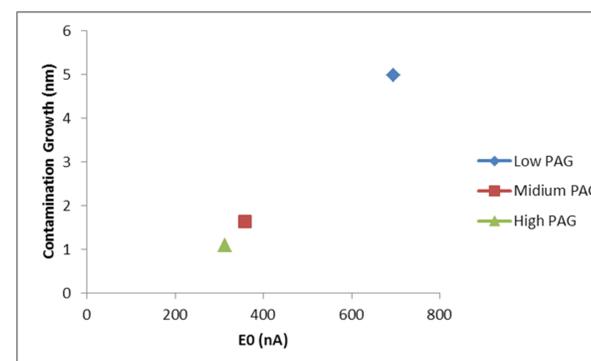


- Contamination growth scales with Protecting Unit and Quencher, and interaction between PAG, Protecting Unit, and Quencher was observed
- When PAG Loading is isolated, high Protecting Unit and high Quencher does result in highest contamination growth



- Different EUV resist family was investigated, with known concentration of PAG
- Low PAG results in highest CG while high PAG results in lowest CG

All resist samples for family test passed non-cleanable reflectivity loss spec.



Conclusion

- We believe SEMATECH is the first group to certify a resist family for witness sample based resist outgas testing
- ASML agreed that 3 samples per family is sufficient for all resist suppliers (LHH, MHH, HHH), and 1 sample per family (LHH) for JSR.
- SEMATECH is continuing working with industry for further improvements towards HVM requirements

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