ROX outgas testing update

Resist TWG
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SEMATECH has the full suite of tools for testing

- Vacuum storage of wafers
- Hydrogen cleaning system
- EUVT and ROX exposure tools

- Physical Electronics Quantera II XPS
- Hydrogen cleaning system

- Woollam M-2000 ellipsometer
ROX tool for ASML witness plate testing
(Lower volume experimental tool)

Second electron gun has been installed and is in commissioning – to allow either electron or photon exposures of the resist

Hybrid system – EUV exposures of resist and electron exposures of witness plate
Cleanables results for customer samples

Over 80 customer samples measured
55% pass cleanables
No significant improvements in materials submitted for testing
Non-cleanables results for customer samples

All customer samples tested pass non-cleanables
Highest contaminating samples were not cleaned or measured
Goal is <10% $3\sigma$ repeatability

Goal is 10% $3\sigma$

Average customer sample repeatability is 6% $3\sigma$

Results < 0.5 nm are not reported
Comparison of cleanables and E0
still no correlation

Cleanables pass if below 3 nm
Comparison of electron exposures with EUV exposures of photoresist

- Two different tools, EUVT with electron exposure of resist and ROX with EUV exposure of resist
- Similar results for contamination growth for the four materials tested on both tools
Research to understand and improve outgas testing

1. Electrons are everywhere causing unwanted resist exposure
2. The potential of molecules from previous exposure affect subsequent exposures in chamber
Electrons go everywhere…

According to simulations with CASINO, 57% of 300 eV electrons are backscattered from a Ru sample, and have a peak energy near 275 eV.

![Backscattered Energy](chart)

Witness plate exposure is ~ 100 µA, but nA to photoresist will cause chemistry!
Prior to certification stray electrons showed unwanted exposure of EUV photoresist

With 12 hour exposure to measure small effect, resist loses more than 10 nm thickness after developing from electron background.

Results of other experiments indicate the thickness lost from these stray electrons is consistent with the < 300 eV electron energy predicted by CASINO.
Residual contamination effect

• Prior exposure affects the thickness of the next exposure – especially obvious after high contaminating resist in prior exposure that day – so chamber contamination is an issue

• The RGA data for likely PAG component below shows residue in chamber hours after exposure

Log scale to show low levels of residual component
To understand the effect of residual contamination of the chamber, witness plate exposures were completed during and AFTER the EUV exposure of the wafer, which was removed from the chamber after exposure.
Conclusions

• Outgas testing of customer samples and research into the outgassing process is underway with the ROX tool.
• Over 80 customer samples tested so far by SEMATECH
  – 100% pass the non-cleanables specification
  – 55 % pass the cleanables specification
• Research to understand the outgassing and determine faster testing methods is underway