

## ROX outgas testing update

Toyama, Japan October 6, 2013

Greg Denbeaux<sup>1</sup>, Jaewoong Sohn<sup>2</sup>, Tonmoy Chakraborti<sup>2</sup>, Dominic Ashworth<sup>2</sup>
Yudhishthir Kandel<sup>1</sup>, Diego Alvarado<sup>1</sup>, Mihir Upadhyaya<sup>1</sup>

<sup>1</sup>CNSE <sup>2</sup>SEMATECH

Special thanks to Bill Colman<sup>2</sup>, Dan Kraft<sup>2</sup>, Jennifer Massier<sup>3</sup>, Chandra Sarma<sup>4</sup>

<sup>3</sup>ASML <sup>4</sup>Intel assignee to SEMATECH





## SEMATECH has the full suite of tools for testing



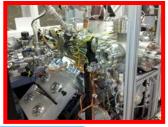
Vacuum storage of wafers



Hydrogen cleaning system



+



EUVT and ROX exposure tools





Hydrogen cleaning system



Woollam M-2000 ellipsometer

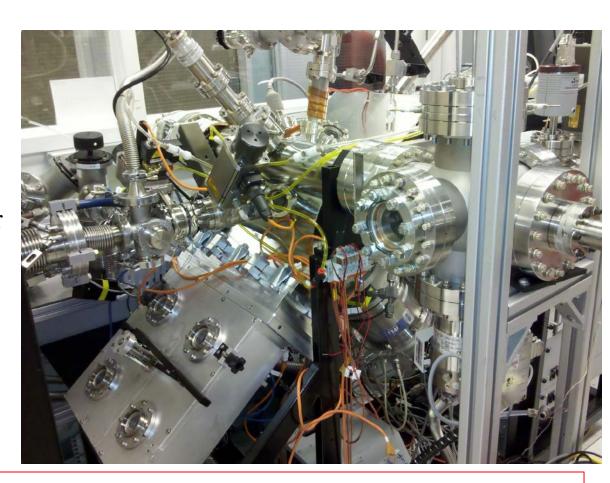






## ROX tool for ASML witness plate testing

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

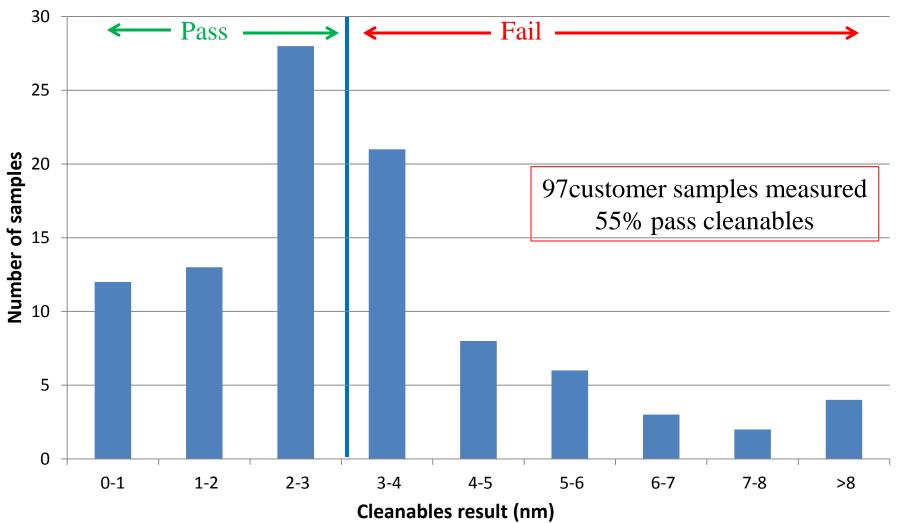


Hybrid system – EUV exposures of resist and electron exposures of witness plate





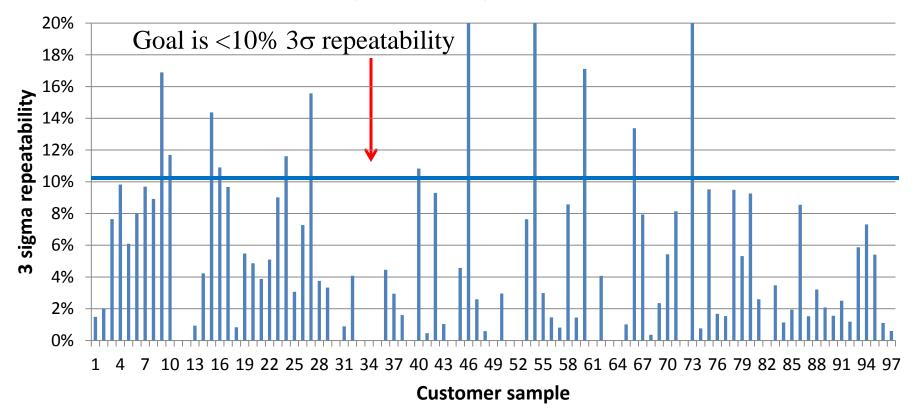
#### **Cleanables Results**







#### Repeatability at ROX



 $Goal is 10\% \ 3\sigma$  Average customer sample repeatability is 6%  $3\sigma$  Results < 0.5 nm are not reported

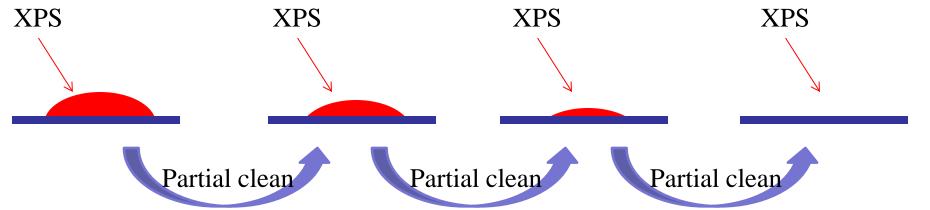
cnse.albany.edu





## Studying the effectiveness of cleaning

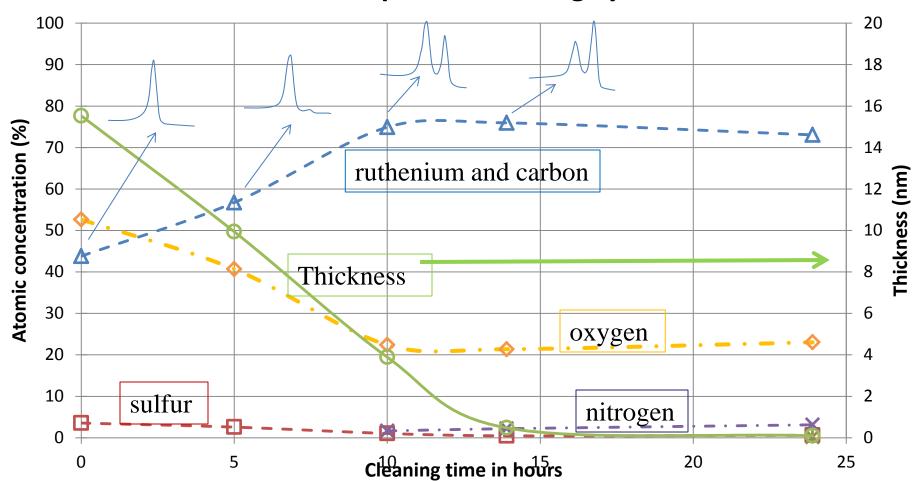
- After 97 customer samples, none have come close to failing the cleaning specification we want to understand why
- We did more in depth measurements of one sample it started with
   15 nm of contamination growth
  - Measured XPS of the contamination spot PRIOR to cleaning
  - Partially cleaned multiple times with XPS after each clean cycle to measure the composition within the contamination, during cleaning, and after cleaning







# XPS composition and ellipsometry thickness results between partial cleaning cycles

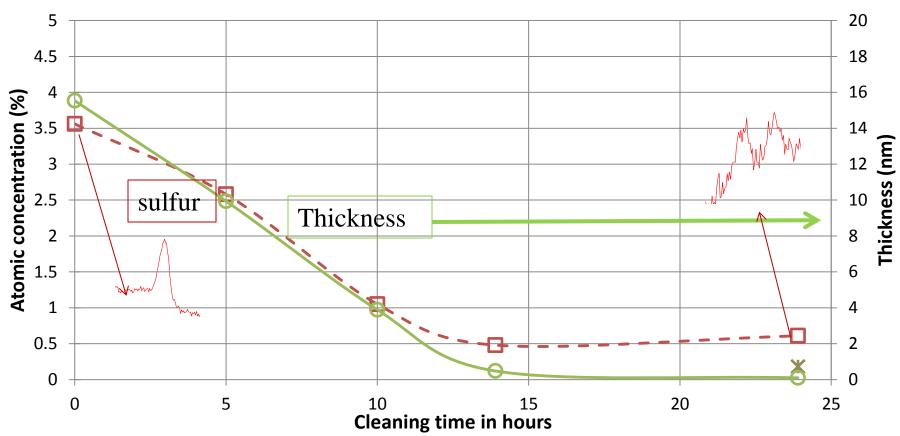


Ruthenium sensitivity factor used for carbon sample gives much lower carbon concentration than is real and affects other concentrations





## Sulfur composition measured during cleaning (NOT corrected for Ru and C sensitivity factor adjustment in XPS)



Measured sulfur concentration drops during cleaning, BUT, that is based on ruthenium calibration for the XPS and NOT the carbon correction So, the actual sulfur cleaning result is still not clear





#### **Conclusions**

- After 97 customer samples, none have failed non-cleanables
- Carbon and ruthenium overlapping peaks make quantification a challenge within the uncleaned spot
  - Spectra shows clear shift from carbon to ruthenium during the cleaning as expected
- No fluorine measured in the spot before, during or after cleaning This supports previous NIST result that fluorine is cleaned during exposure
- There is sulfur in the contamination spot
  - Sulfur content appears to reduce, but understanding actual cleaning will take more XPS analysis
- Original sulfur peak shifts to both sulfur and sulfur oxide during the cleaning and storage of the sample. Even though oxygen was present in the contamination spot, it was not bound to sulfur