



ROX outgas testing update

Resist TWG
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SEMATECH has the full suite of tools for testing



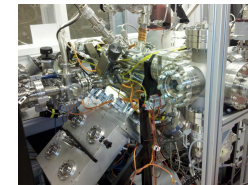
Vacuum storage
of wafers



Hydrogen
cleaning system



+



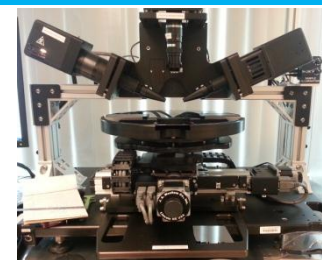
EUVT and ROX
exposure tools



Physical
Electronics
Quantera II XPS

Hydrogen
cleaning system

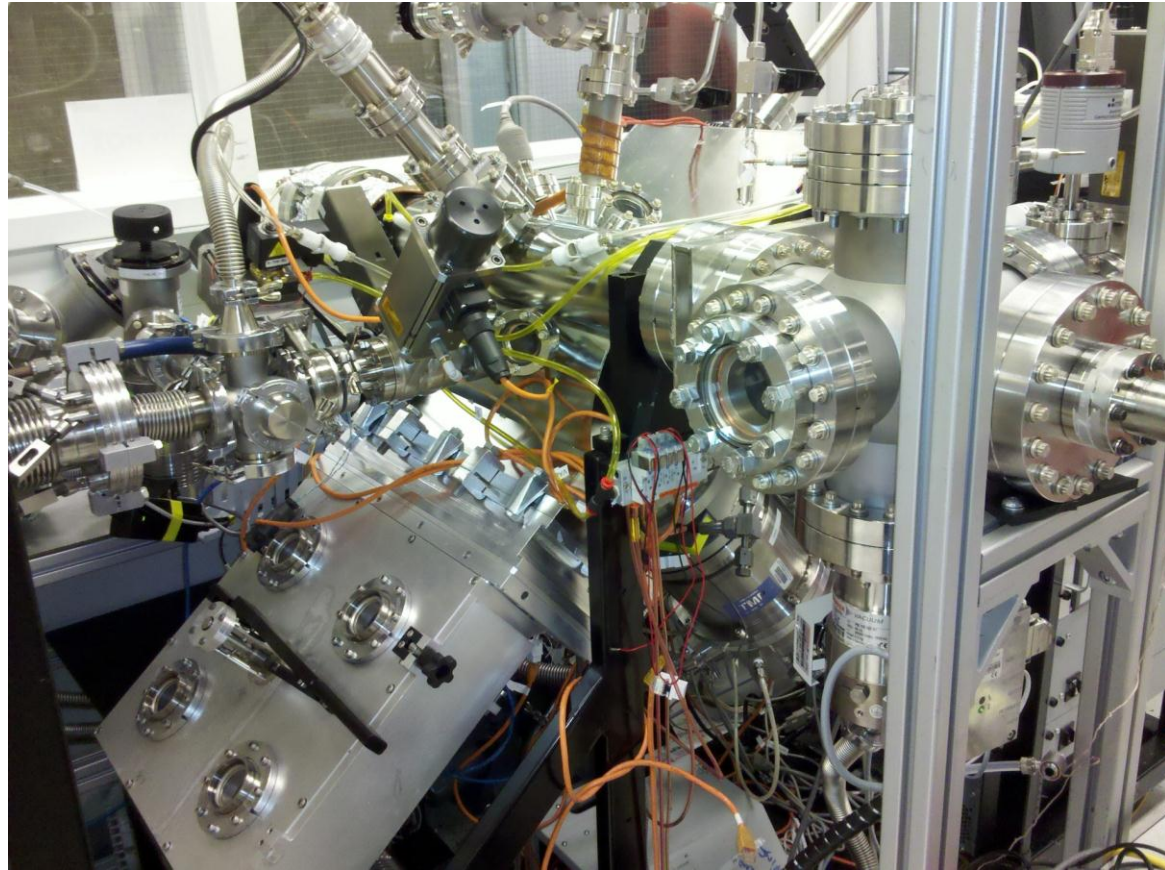
Woollam
M-2000
ellipsometer





ROX tool for ASML witness plate testing (Lower volume experimental tool)

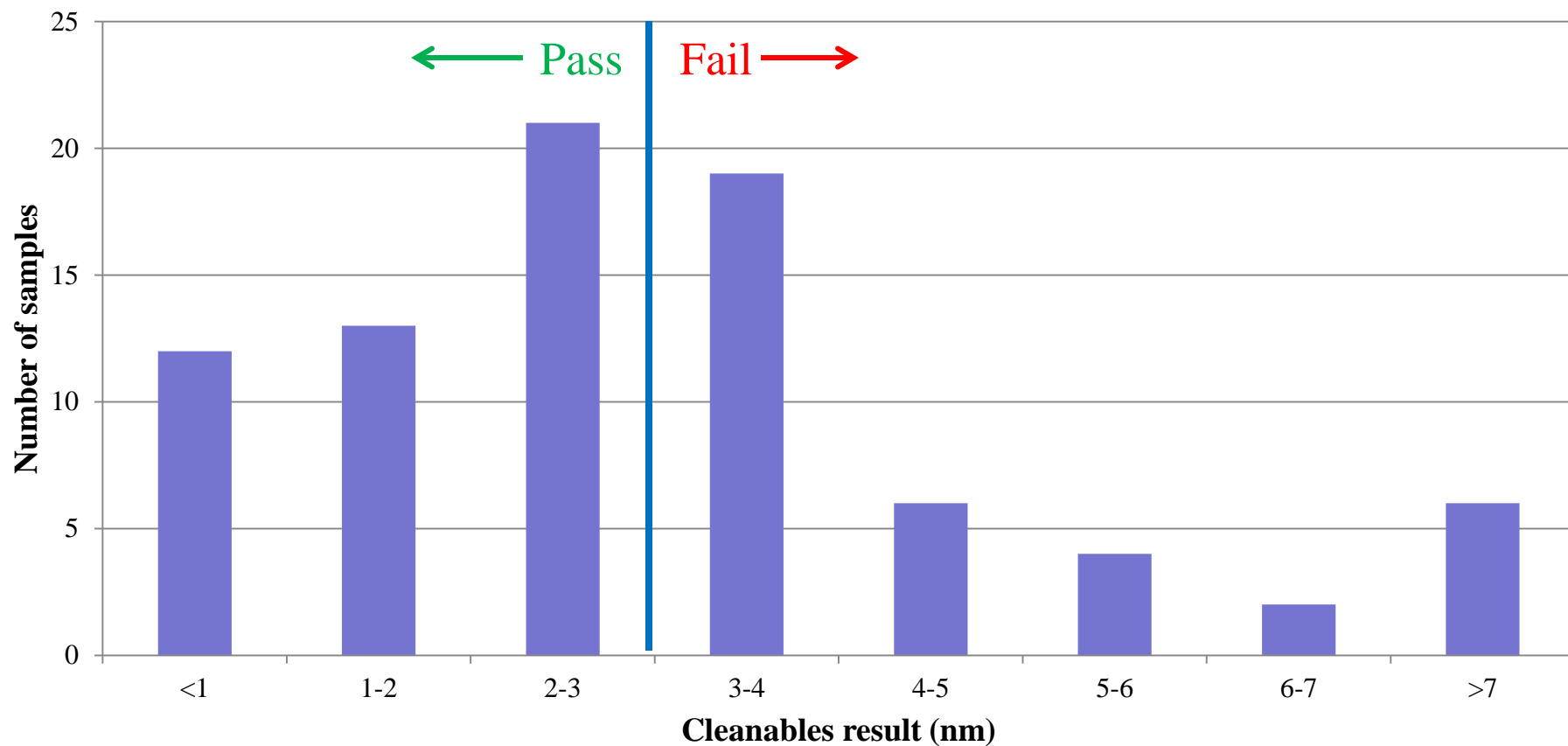
Second electron gun has been installed and is in commissioning – to allow either electron or photon exposures of the resist



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



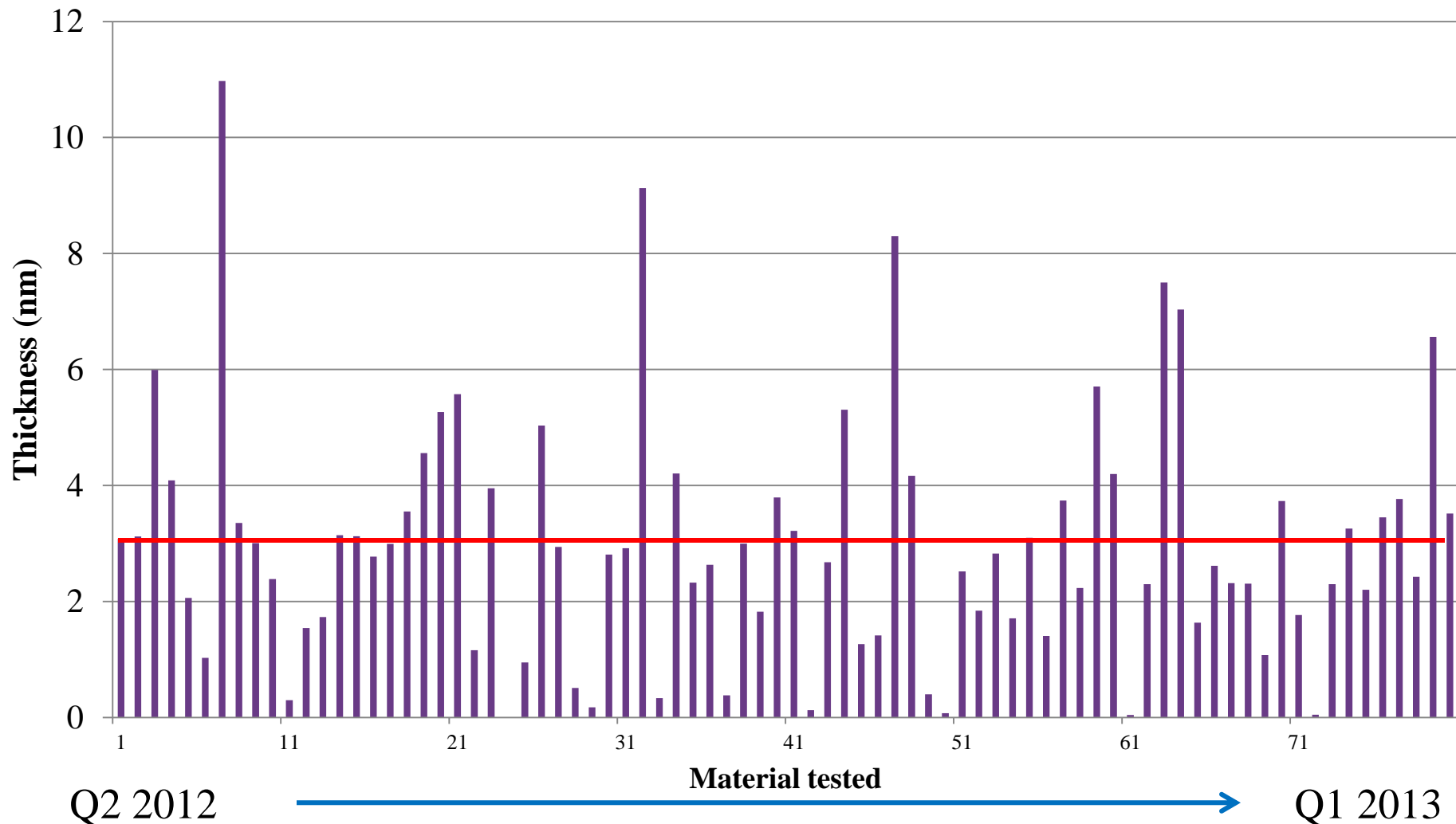
Cleanables results for customer samples



Over 80 customer samples measured
55% pass cleanables

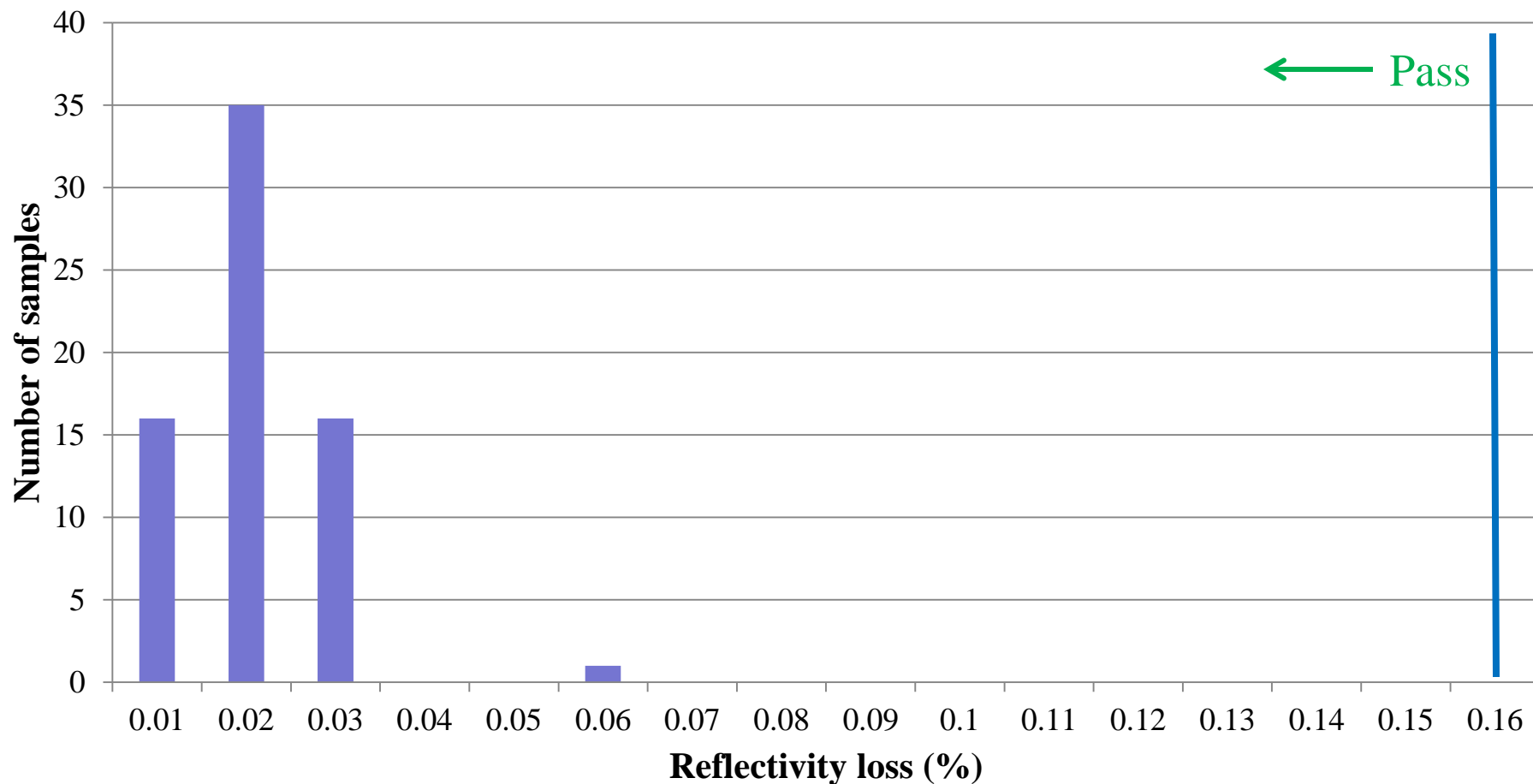


No significant improvements in materials submitted for testing





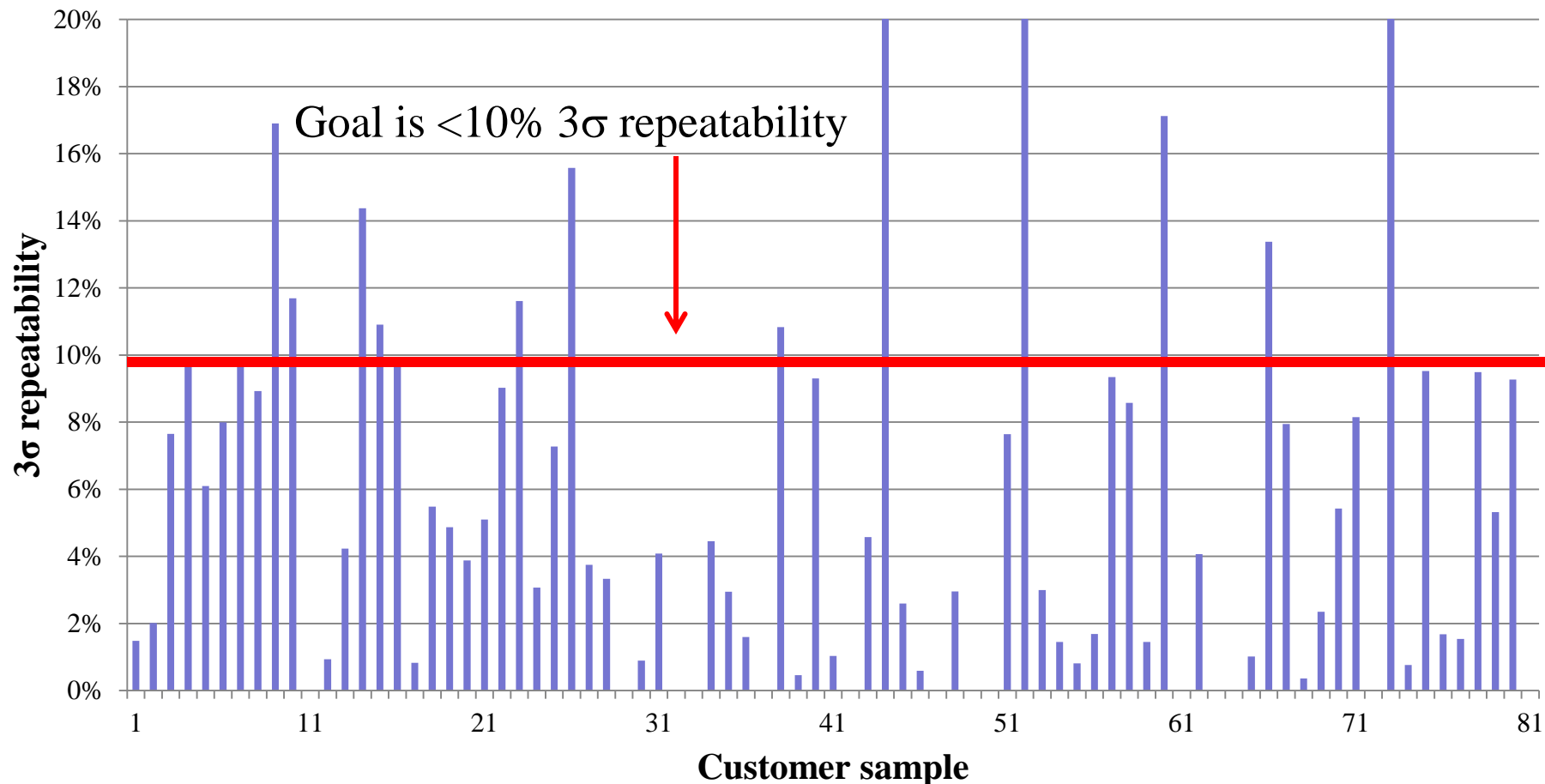
Non-cleanables results for customer samples



All customer samples tested pass non-cleanables
Highest contaminating samples were not cleaned or measured



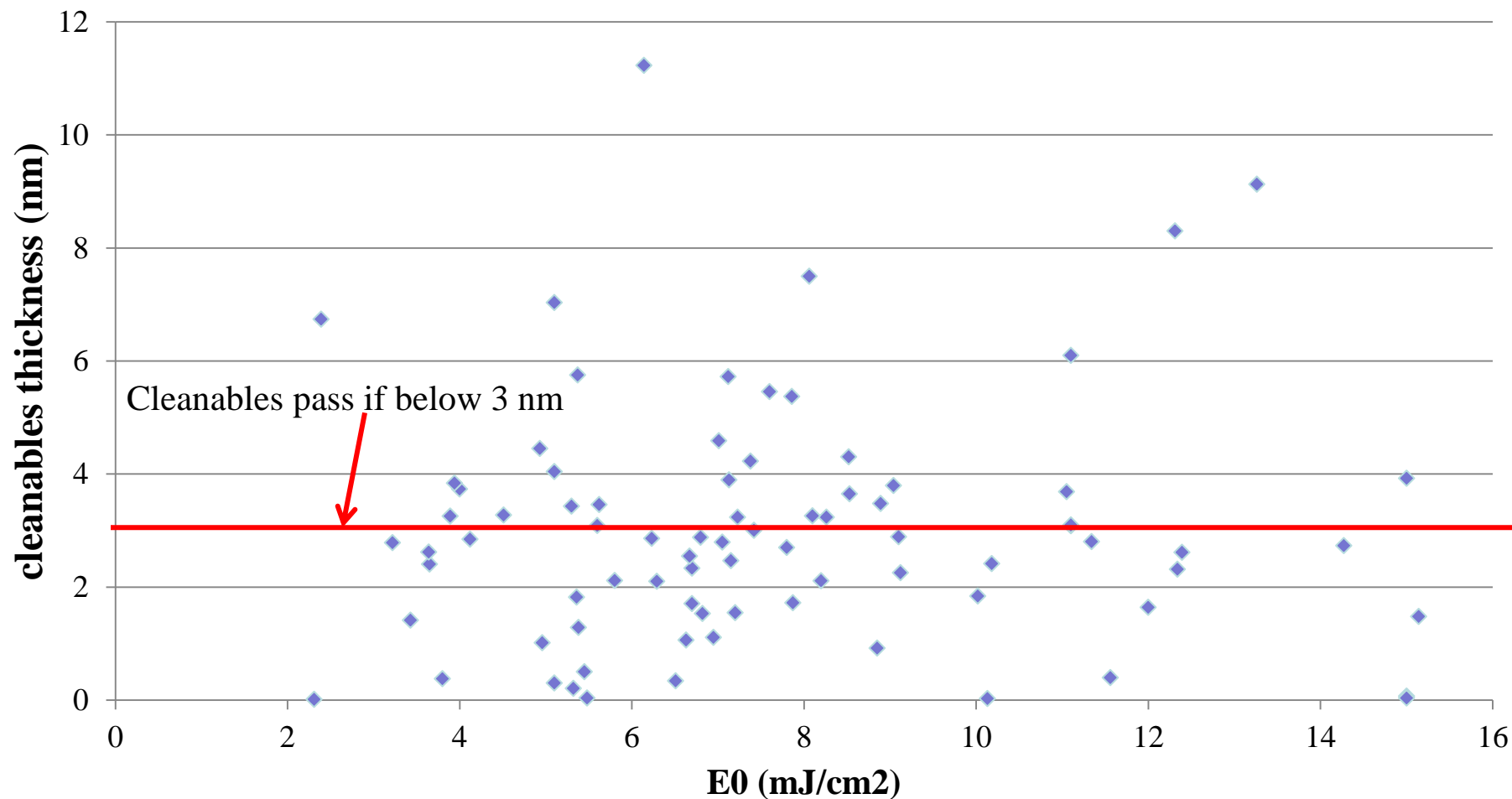
Repeatability at ROX



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

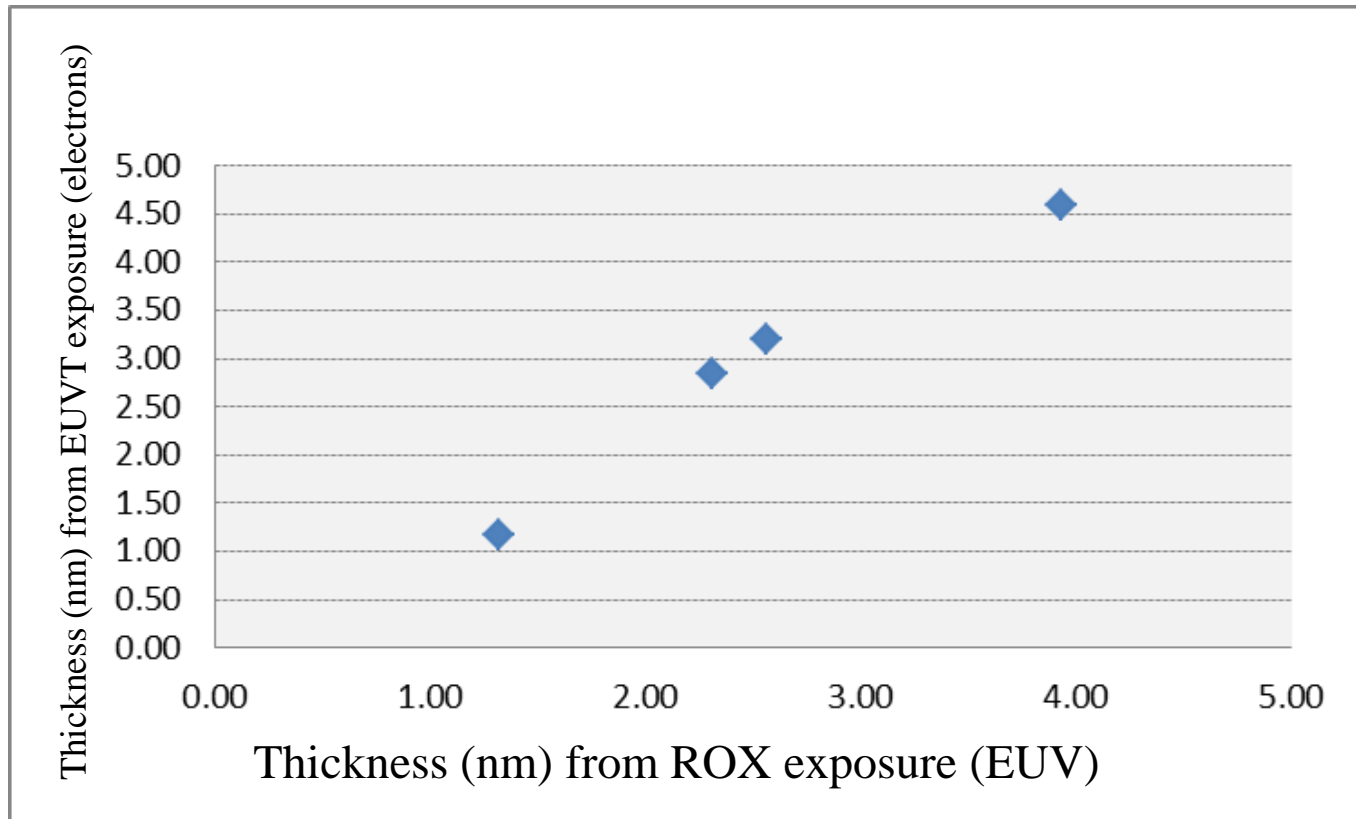


Comparison of cleanables and E0 still no correlation





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



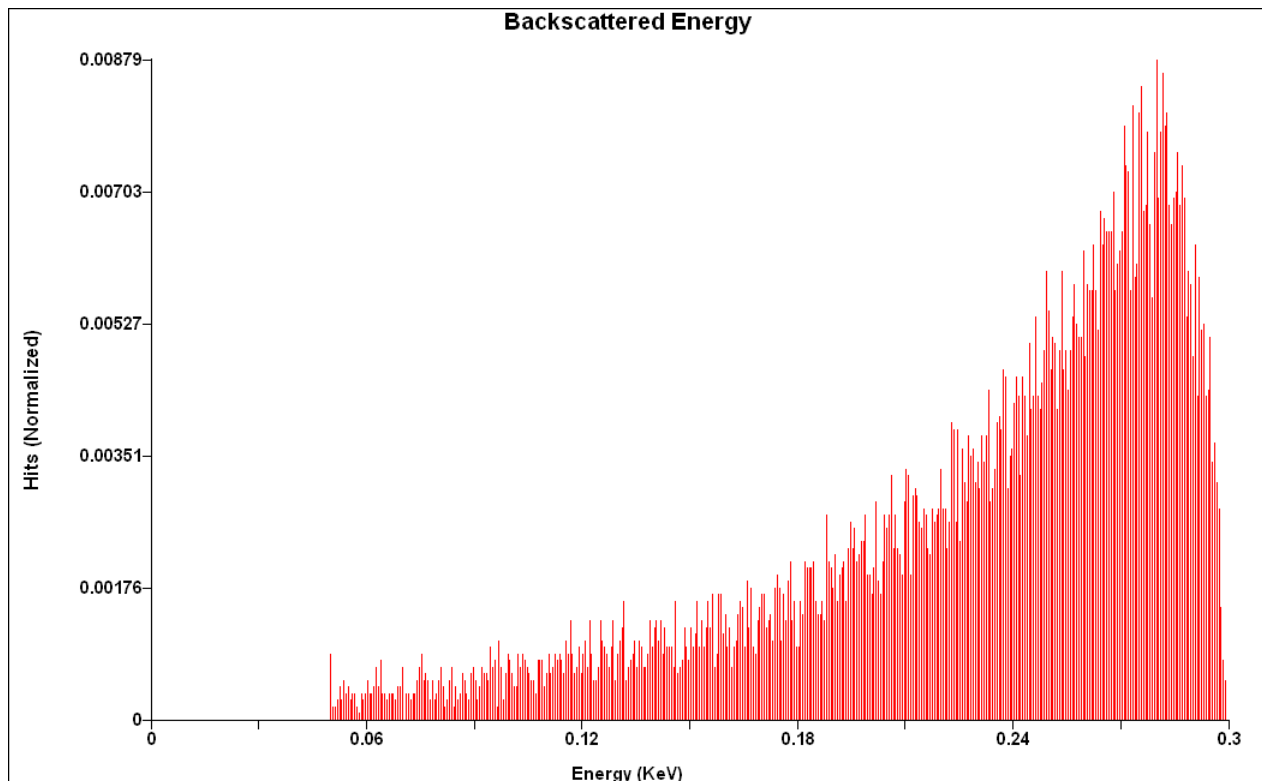
Research to understand and improve outgas testing

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



Electrons go everywhere...

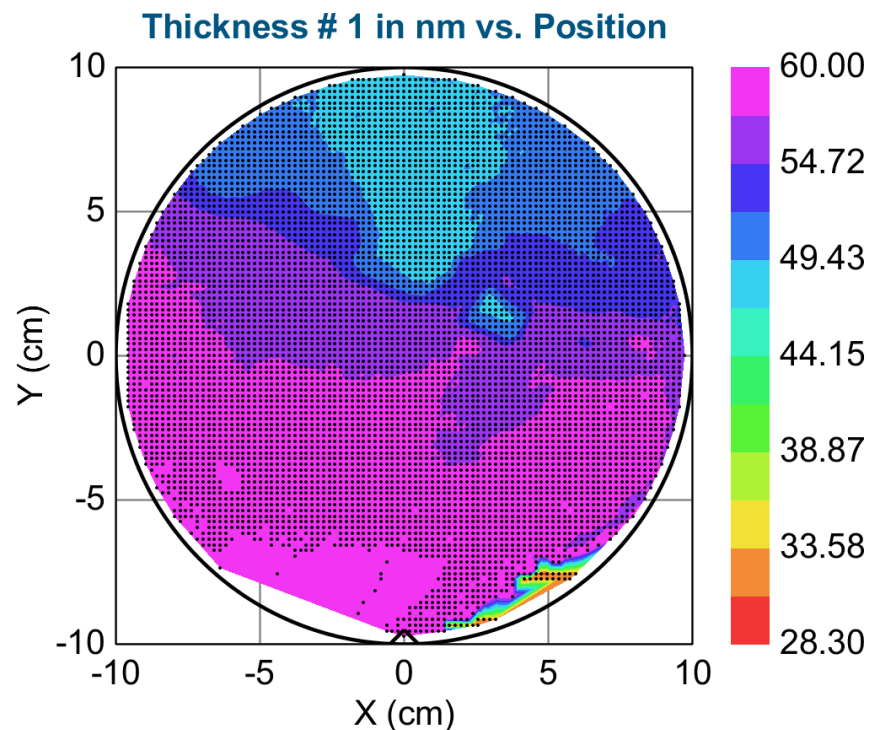
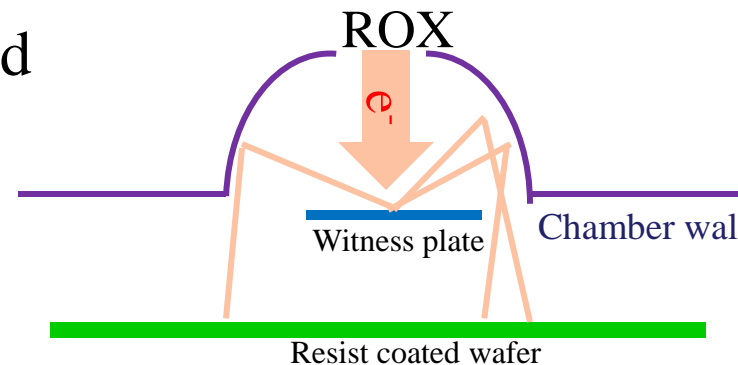
According to simulations with CASINO, 57% of 300 eV electrons are backscattered from a Ru sample, and have a peak energy near 275 eV



Witness plate exposure is $\sim 100 \mu\text{A}$, but nA to photoresist will cause chemistry!

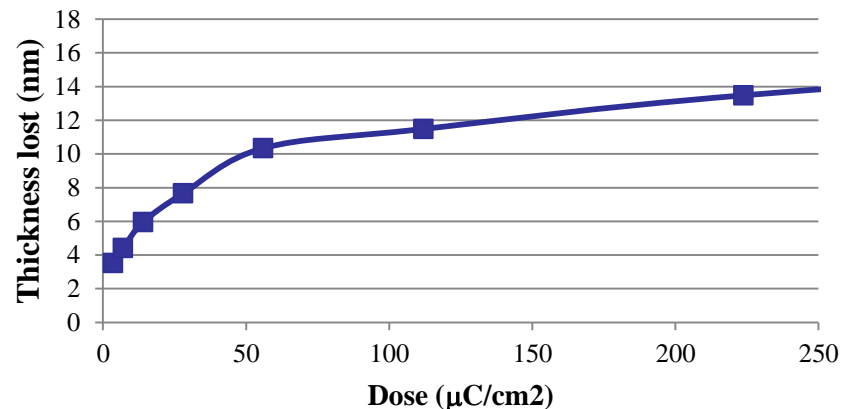


Prior to certification stray electrons showed unwanted exposure of EUV photoresist



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

50 eV incident electrons

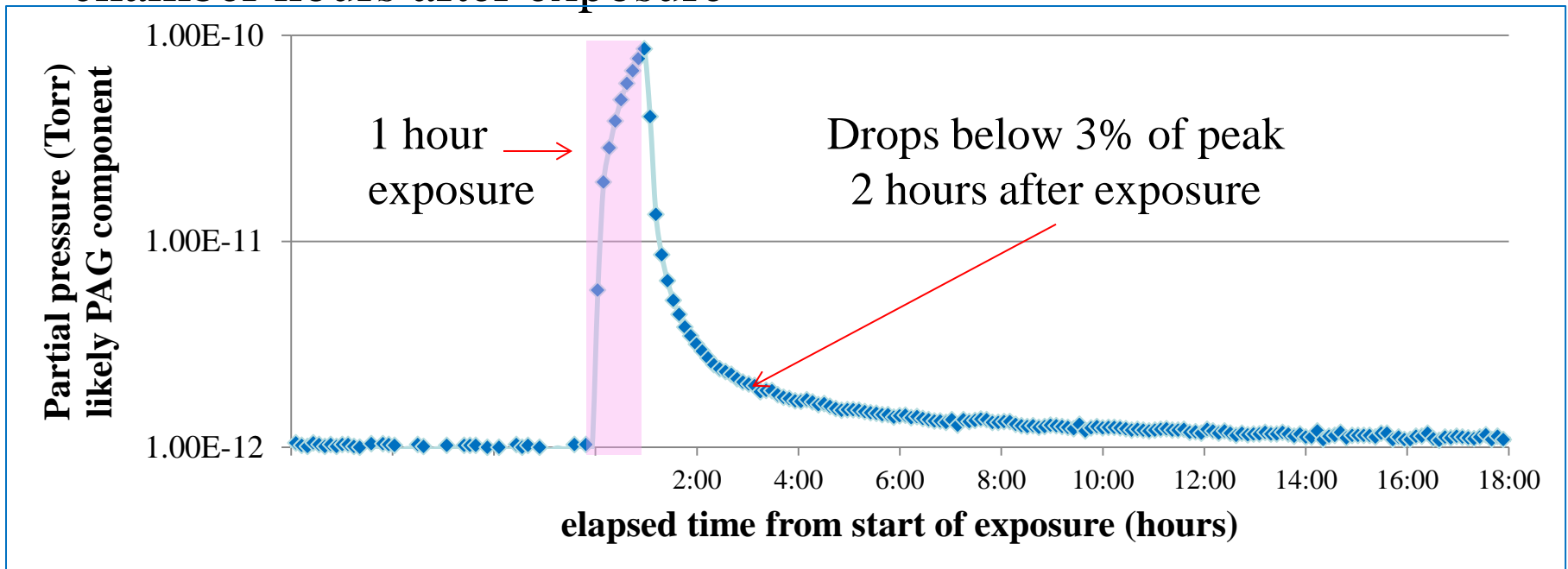


Results of other experiments indicate the thickness lost from these stray electrons is consistent with the < 300 eV electron energy predicted by CASINO



Residual contamination effect

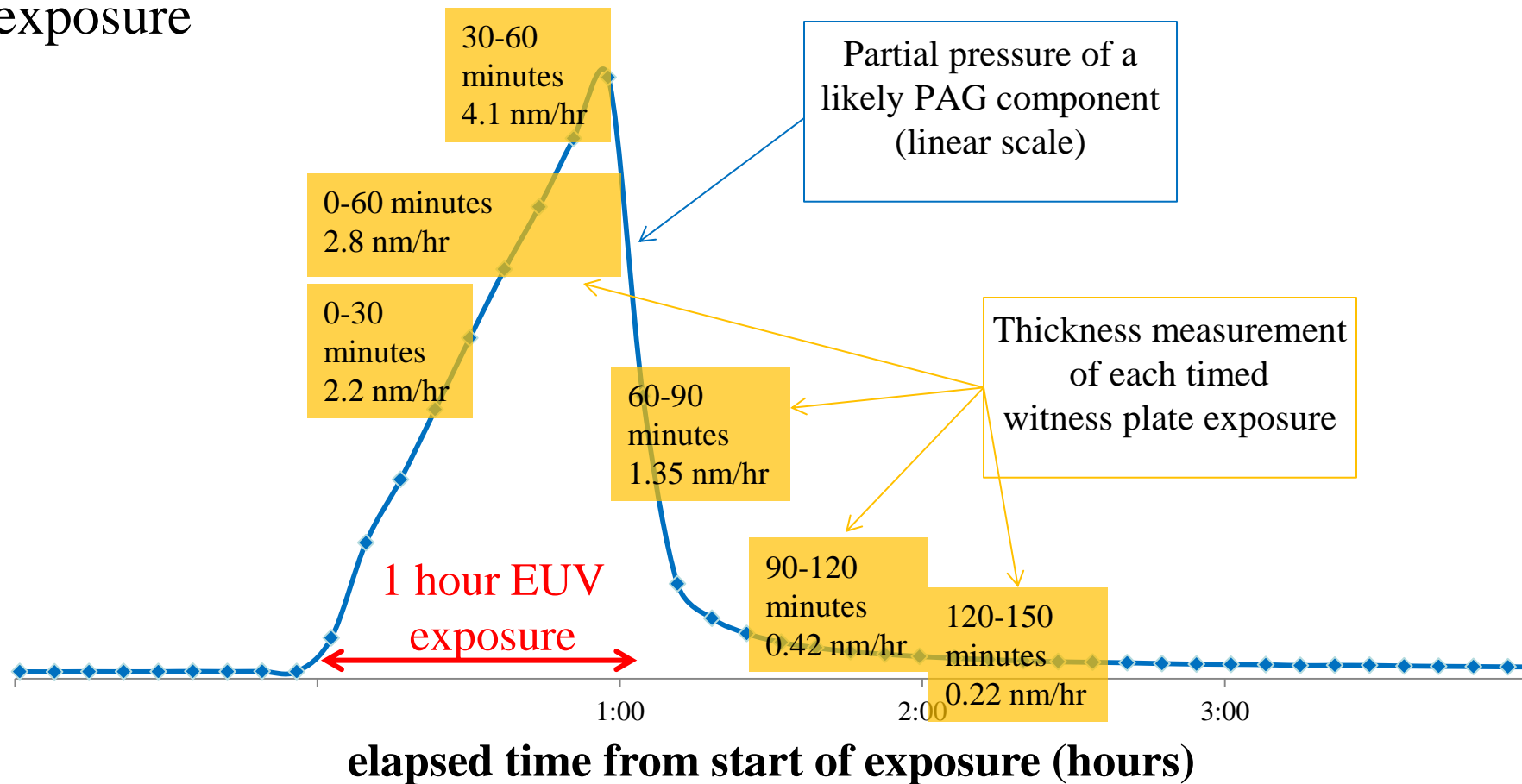
- Prior exposure affects the thickness of the next exposure – especially obvious after high contaminating resist in prior exposure that day – so chamber contamination is an issue
- The RGA data for likely PAG component below shows residue in chamber hours after exposure



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