# NIST resist outgas testing update

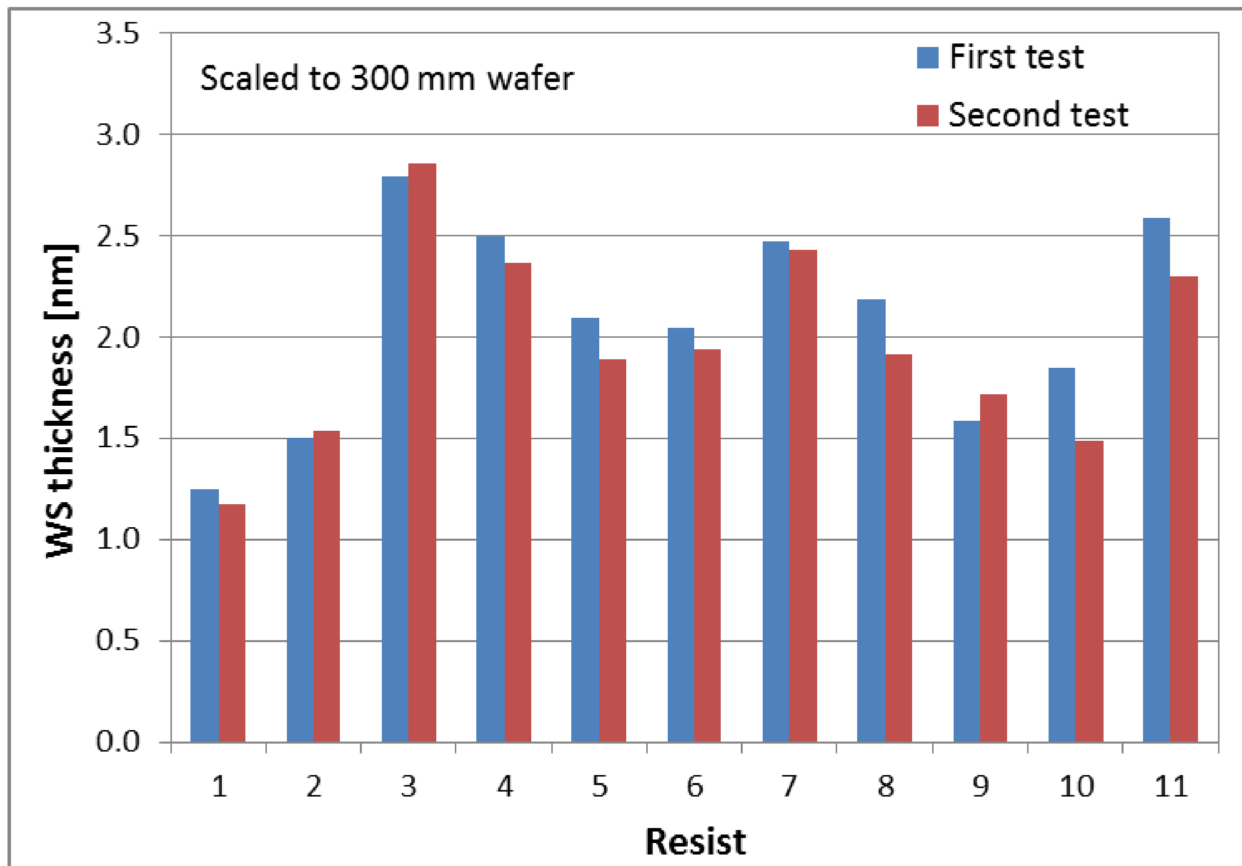
**S. B. Hill, C. Tarrio, B. Berg, N. Faradzhev,
S. Grantham and T. B. Lucatorto**

*National Institute of Standards and Technology
Gaithersburg, MD  20899  USA*

- NIST will remain shutdown until the US Federal Government resumes "normal" operations.
- No access to NIST email or voicemail.  Alternative contact info:
  - ➢ S.hill.away@gmail.com
  - ➢ tom.lucatorto@gmail.com

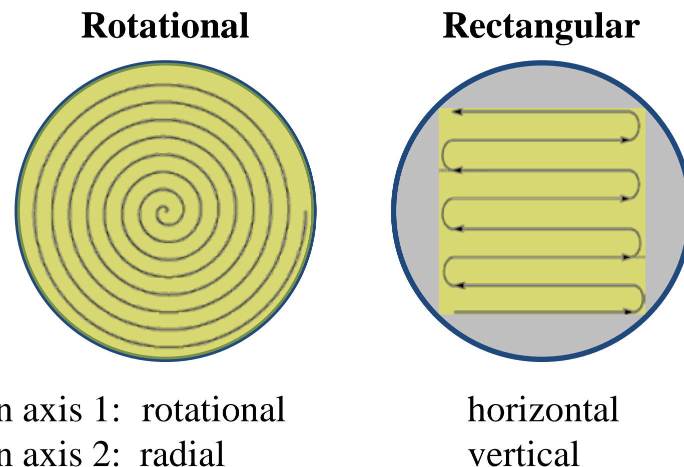
# Resist-outgas testing at NIST

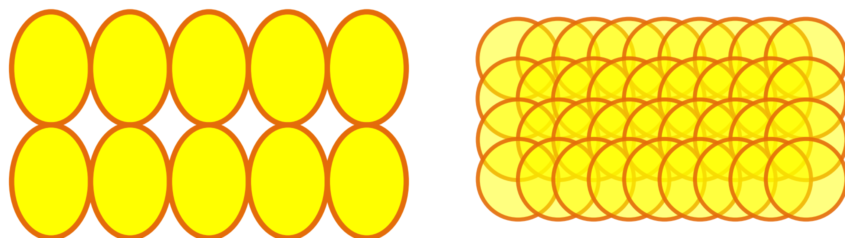
- Capacity for 6 resists per month.
- Only 5 customer-requested tests since February 2013 (all passed)
- Two separate tests for each resist show good reproducibility (2011-2012)



# Compare exposure dynamics at different facilities

- Correlations might explain inter-facility variations
- Wafer source dynamics (fast time scale)
  - Pulse frequency: <1 kHz to >100 MHz
  - Pulse duration: < 1 ns to >200 ns
  - Duty factor: $<10^{-4}$ to $10^{-1}$
- Wafer scanning sequence (slow time scale)
  - Rotational or rectangular scan?
  - Continuous scan or step?
  - Beam size (FWHM: full width at half max)
  - Deliver E0 in single step or multiple passes?



# Requested information on exposure dynamics

**Spreadsheet will be sent to all test facilities**

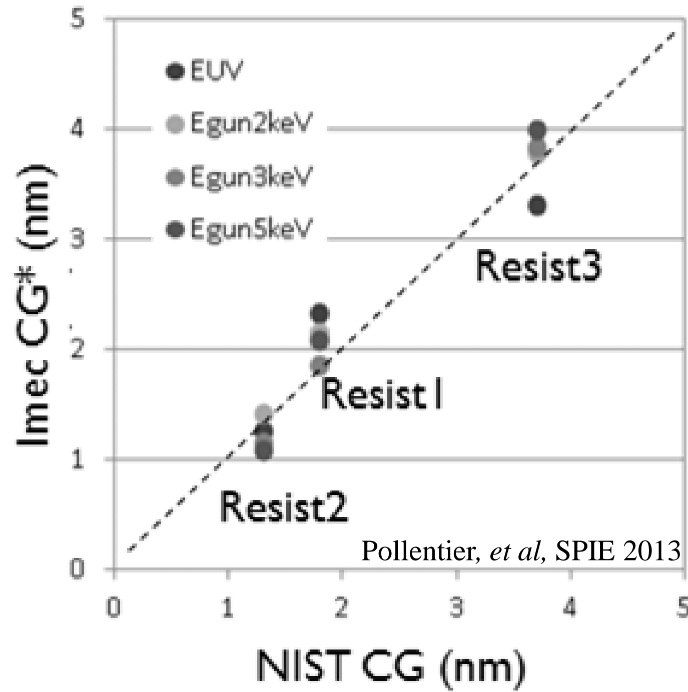
| | WITNESS SAMPLE irradiation | | | | RESIST irradiation | | |
|---|---|---|---|---|---|---|---|
| **Site** | **Method** | **Average intensity** | **Pulse duration** | **Repitition rate** | **Method** | **Pulse duration** | **Repitition rate** |
| NIST | broadband EUV | ~20 mW/mm2 | 1 ns | 113 MHz | in-band EUV | 1 ns | 113 MHz |
| | broadband or in-band EUV or xx keV electrons | xx mW/mm2 or xx A/mm2 | | | broadband or in-band EUV or xx keV electrons | | |

| | Wafer scan axis 1 | | | Wafer scan axis 2 | | | |
|---|---|---|---|---|---|---|---|
| **Site** | **Direction** | **Scan speed or step size** | **FWHM of beam** | **Direction** | **Scan speed or step size** | **FWHM of beam** | **Exposed wafer area [cm2]** |
| NIST | Rotational | 37 mm/s | 5 mm | Radial | 0.25 mm | 2 mm | 310 |
| | Horizontal or rotational | | | Vertical or radial | | | |

# Ongoing work

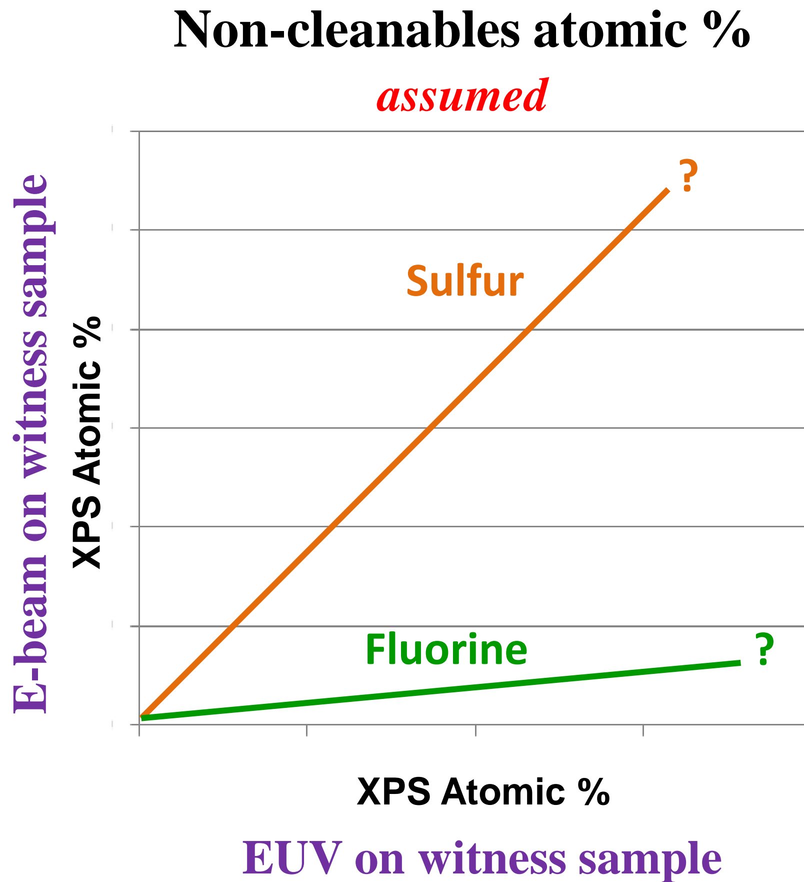
- Establish EUV/e-beam correlation of "non-cleanables" portion of resist outgas test
- Measure AH cleaning rate as a function of EUV dose

# EUV/e-beam correlation of C growth




- Resist-independent correlation measured by
  - ASML certification
  - Bi-lateral NIST-Imec
  - Sematech round robin
- Expect mass-limited growth to be independent of
  - Exposure method (EUV vs. e-beam)
  - WS intensity (above saturation)

# EUV/e-beam correlation of “non-cleanables”




- Linear correlation for EUV/e-beam on WS?
- Order of magnitude of correlation factor?
  - Prelim data suggests electrons desorb F 100x more strongly than EUV
- Does correlation vary with element
  - Prelim data suggests F desorbs much more readily than S.
- Does correlation vary with WS intensity?
  - Prelim data suggests F content of outgas contamination *increases* with *decreasing* witness sample intensity.
- Conflicting implications of high intensity on witness sample during outgas test
  - ✔ Ensures maximum mass-limited C growth
  - ⚠ May underestimate F contamination of NXE optics with lower intensity.

# AH cleaning rate as a function of EUV dose

- Confirm many qualitative observations of slower cleaning rates for C growth (CG) exposed to high EUV/e-beam doses.

- Will CG produced in slow-growth, high-dose NXE environment be significantly harder to clean than fast-growth, low-dose CG produced by outgas test?