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6/24/2011

Cleaning of Capped Multi-Layer Samples and Cleaning with Hydrogen using the Evactron® De-Contaminator (P23)

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XEI Scientific, Inc., Redwood City, CA, USA

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Overview of Talk

- Description of Evactron De-Contaminator and remote (downstream) plasma cleaning
- Using oxygen-containing gas to clean EUV optics and substrates
  - Cleaning rates with room air
  - Results from CXRO
  - Results from U. Albany
  - Results from SEMATECH
- Cleaning with hydrogen

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Evactron De-Contaminator

<u>Plasma Radical Source (PRS) includes</u>

- Valve assembly for metered flow of gas
- Pressure sensor
- RF impedance matching network
- Unique, patented RF electrode (not seen)

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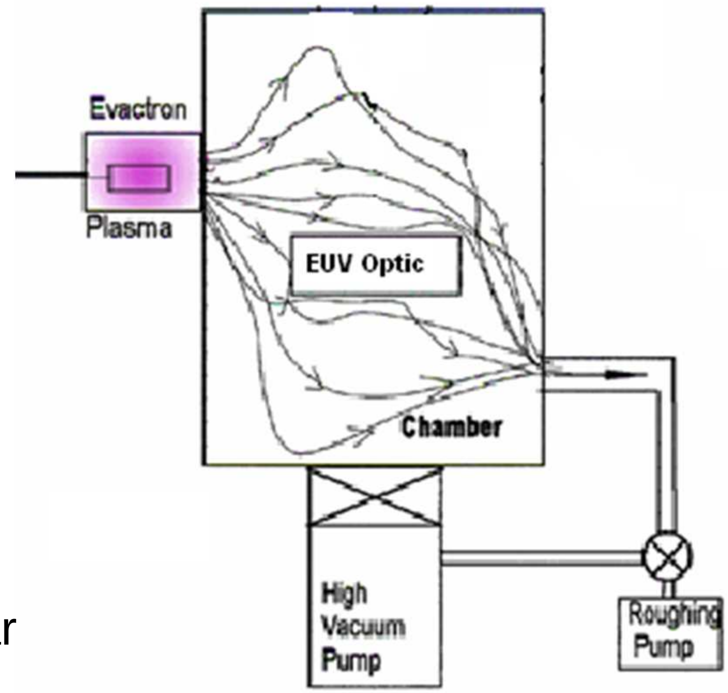
Remote (Downstream) Plasma Cleaning

- The Evactron De-Contaminator is mounted on the left side of the chamber.
- In the Evactron Plasma, radicals are created.
- The radicals flow from the Evactron De-Contaminator to the pump port.
- The radicals chemically react *inside the chamber* with any hydrocarbon contamination they encounter.
- The plasma is confined to the region near where the Evactron De-Contaminator is mounted. Beyond this region, the temperature increase is <5ºC



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Cleaning Rates with Room Air

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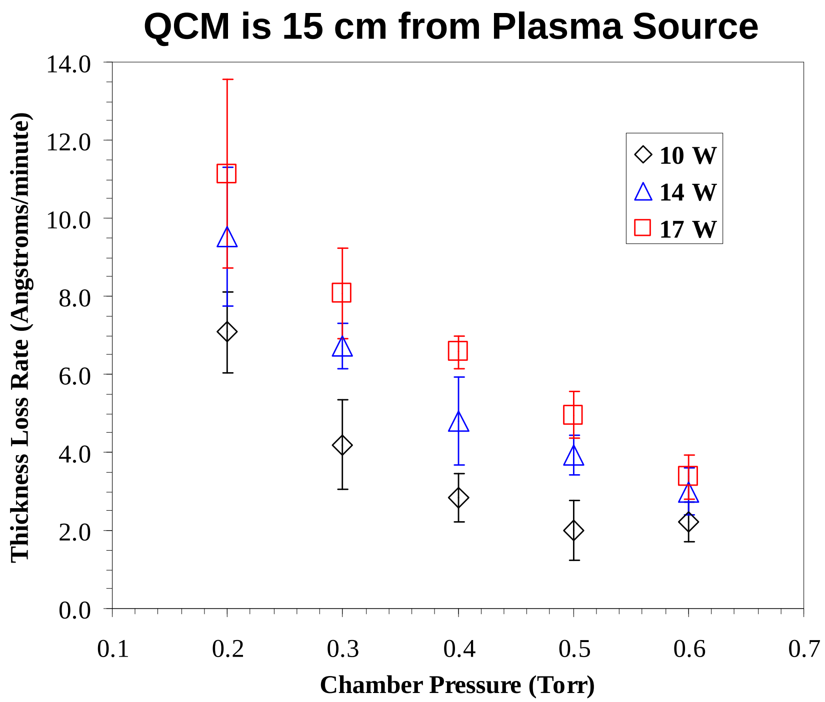
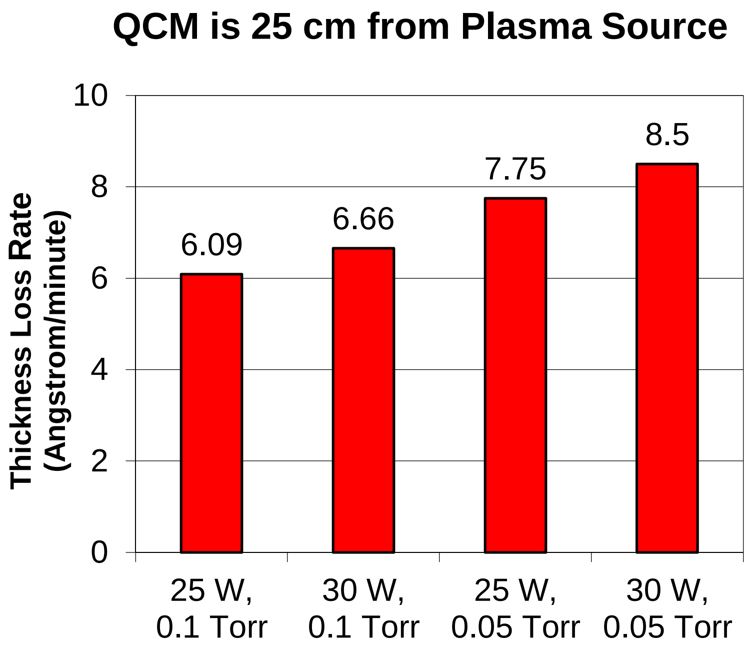
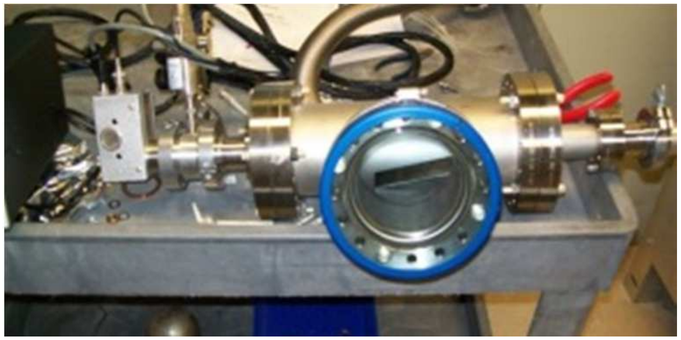




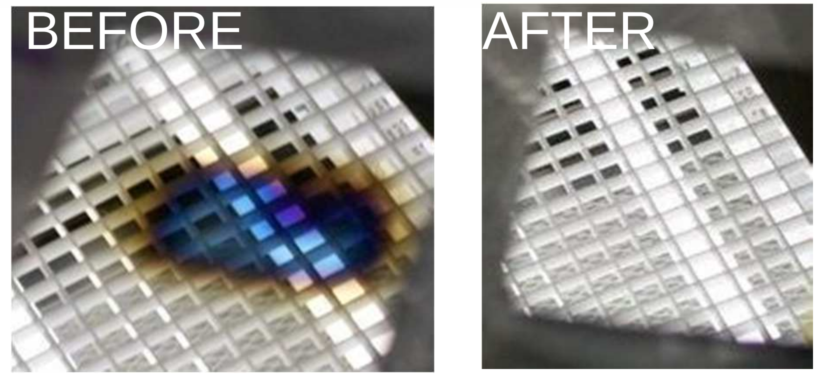
- Data taken using Quartz Crystal Microbalances (QCMs) coated with a thin layer (10-50 nm) of hydrocarbon contamination (pump oil).
- Cleaning rates *increase* as *pressure decreases* and *RF power increases*.
- Cleaning rates *decrease* as the *distance* between the cleaning target and the plasma source *increases*.

Cleaning Si-capped EUV Optics

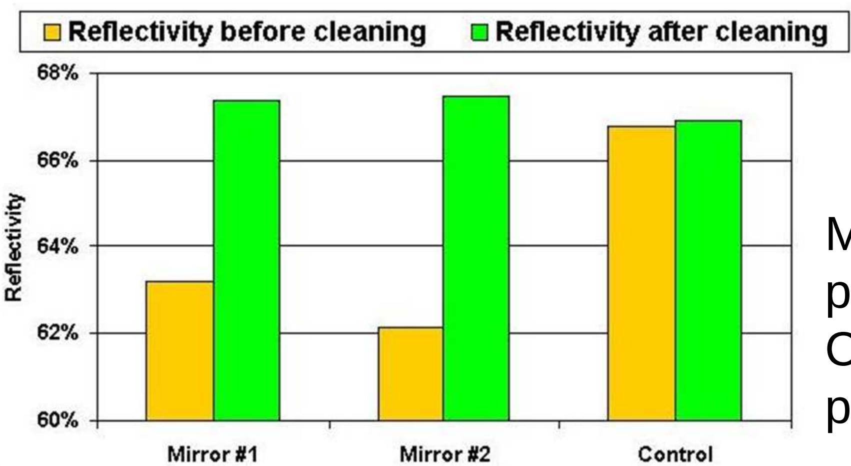
6/24/2011



Test chamber at CXRO used for cleaning Si-capped EUV optics



Senajith B. Rekawa, Paul E. Denham, Brian H. Hoef, Michael S. Jones, and Patrick P. Naulleau
Center for X-Ray Optics
Lawrence Berkeley National Laboratory



ML mirrors (#1 & #2) are contaminated prior to Evactron cleaning.
Control mirror was uncontaminated prior to Evactron cleaning.

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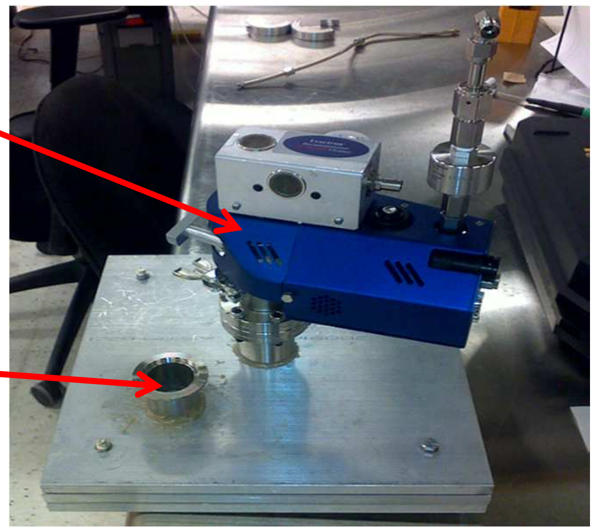
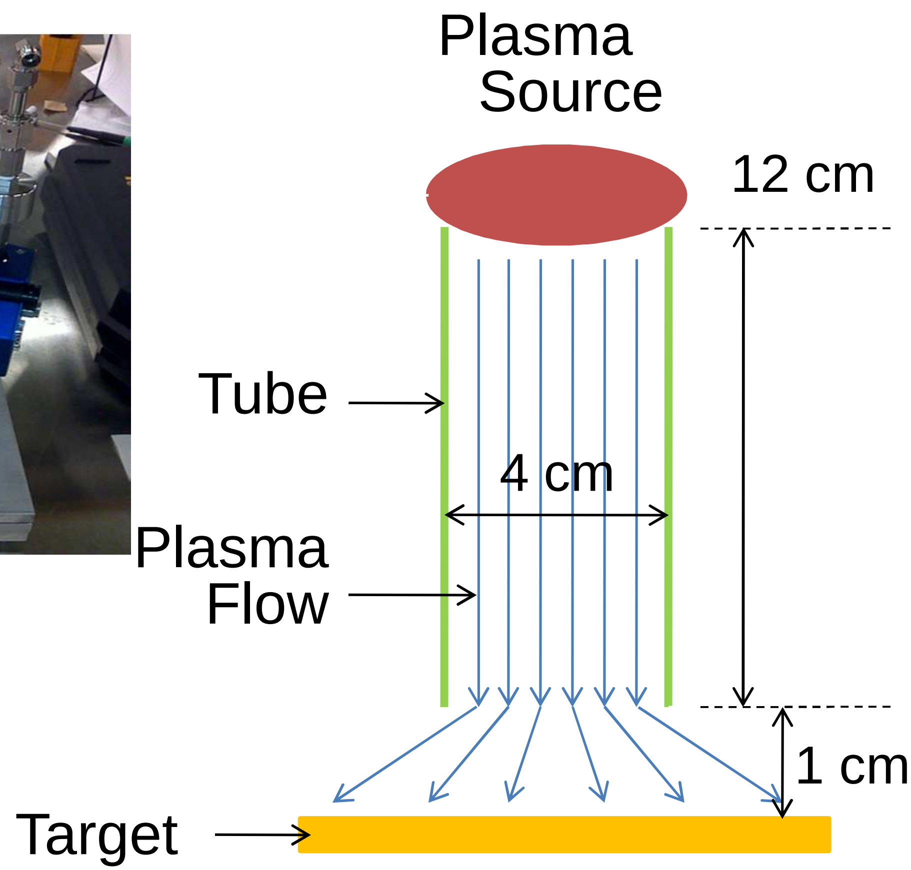
Cleaning Resist with Oxygen/Argon

Evactron Cleaning of PMMA Resist on Si Wafer

Evactron DC located at the center of mask chamber

Exhaust Port





Mihir Upadhyaya and Greg Denbeaux
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Cleaning Resist with Oxygen/Argon

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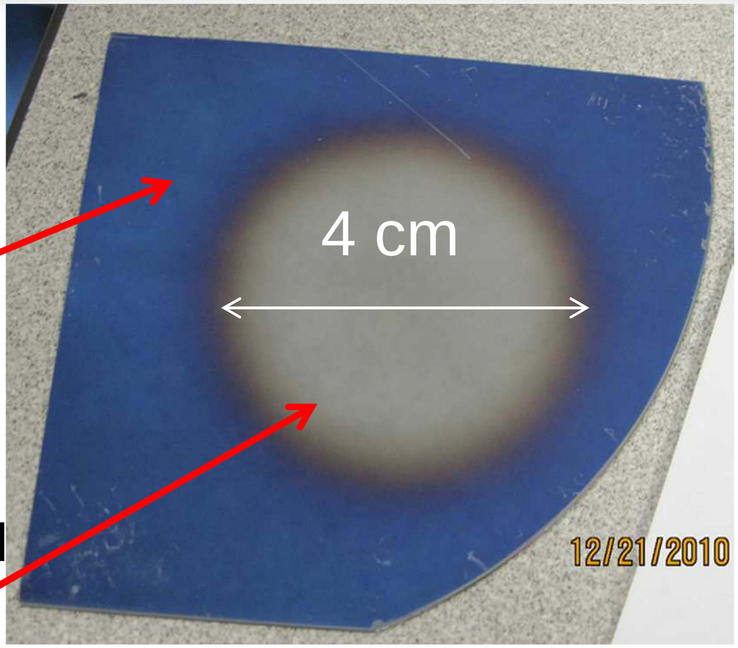
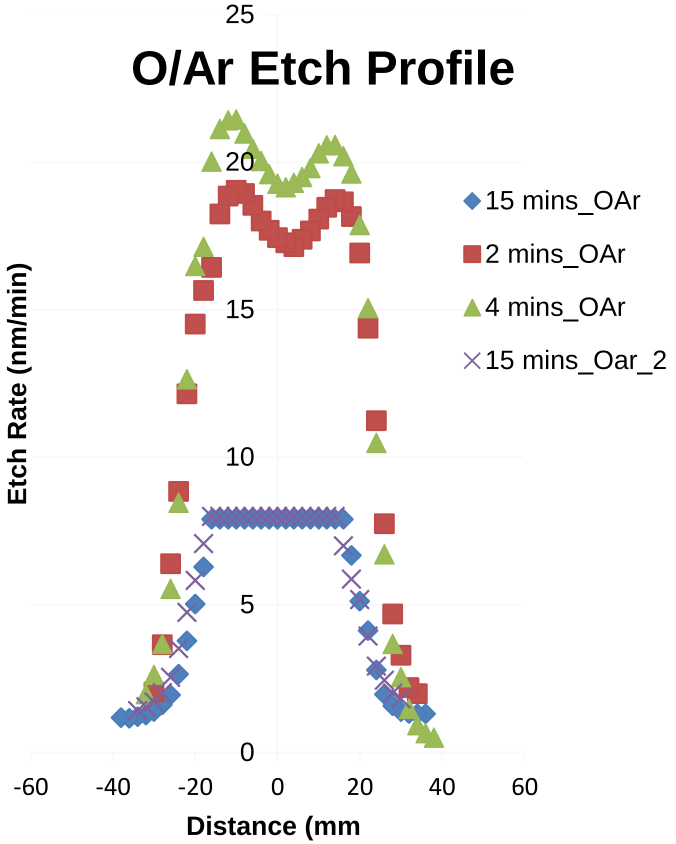
Resist Coated Wafer

Plasma Cleaned Wafer

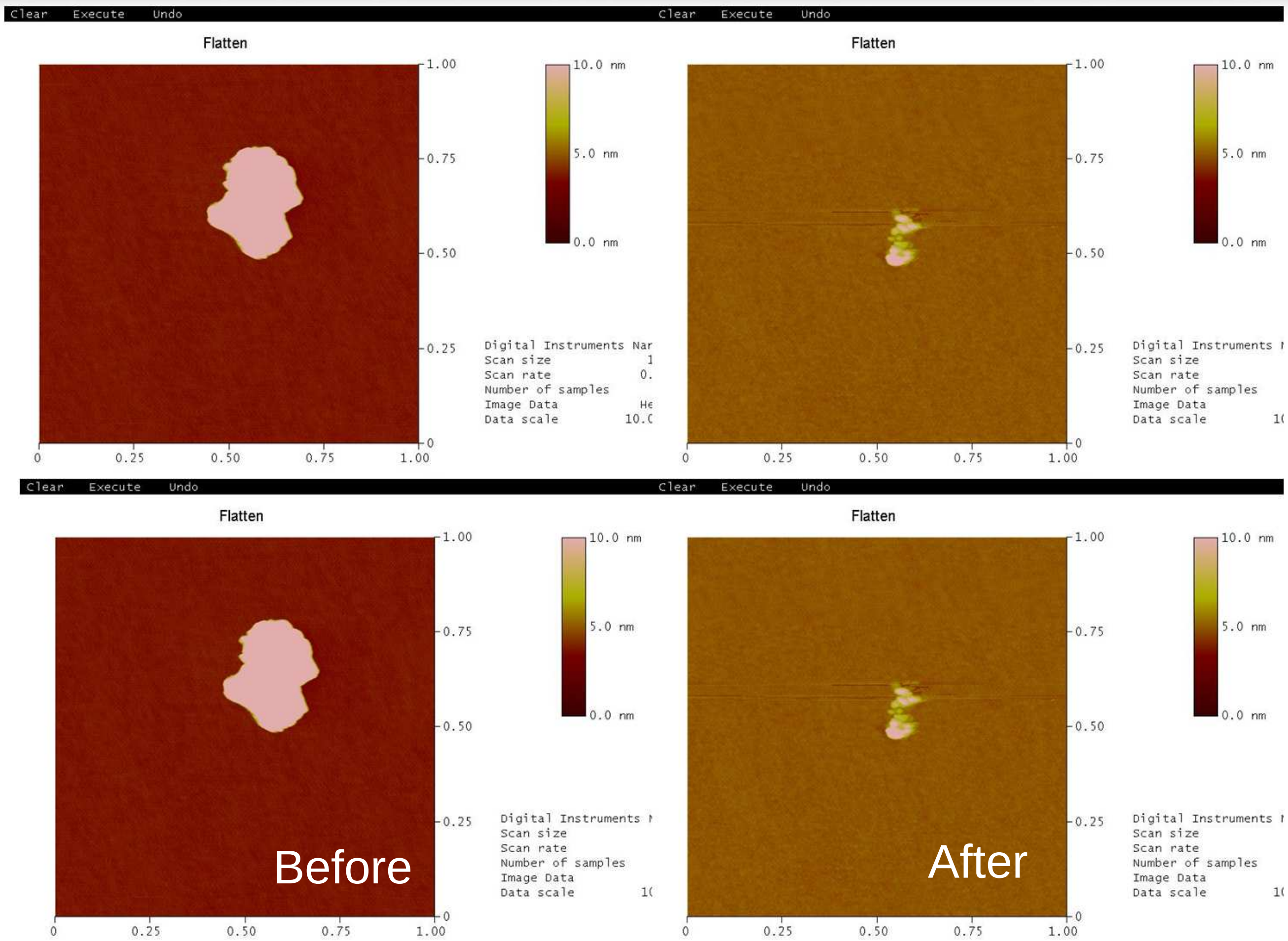




- Plasma Power = 20 W
- Plasma Pressure = 300 mTorr
- ~1/1 Oxygen/Argon mixture
- Cleaning Times: 4-15 minutes

Cleaning Quartz Mask Substrates

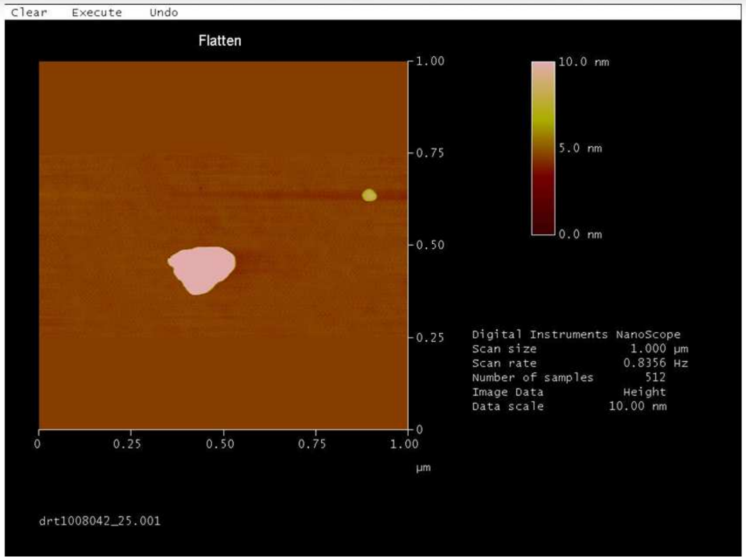
June 24, 2011



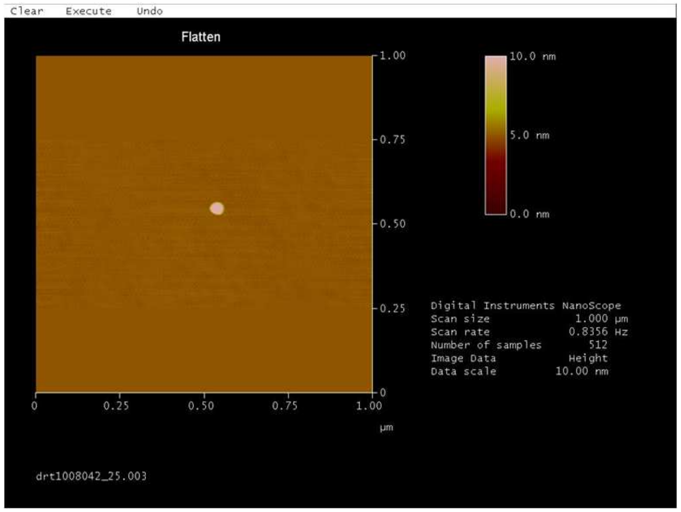
- Room air
- Pressure=300 mTorr
- Power=20 W.
- Time = 1 hr.
- No particle filter attached.
- Unacceptable amount of particles added during the process

Vibhu Jindal, Frank Goodwin, Patrick Kearney, SEMATECH, Albany, NY

Cleaning Quartz Mask Substrates (cont.)



Before



After

- Room air
- Pressure=250 mTorr
- Power=20 W.
- Time = 1 hr.

SEMATECH

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Cleaning Quartz Mask Substrates (cont.)

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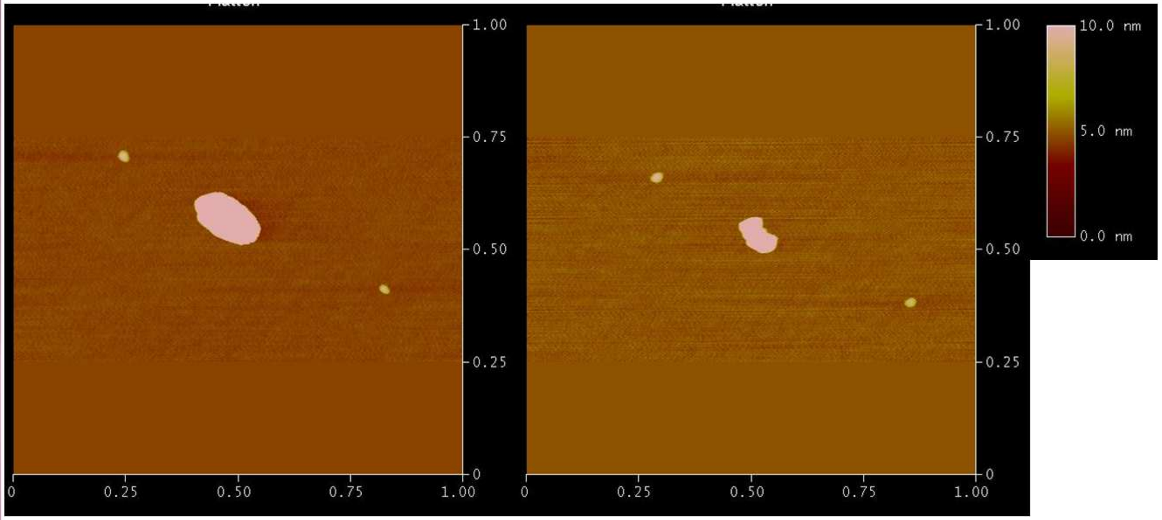
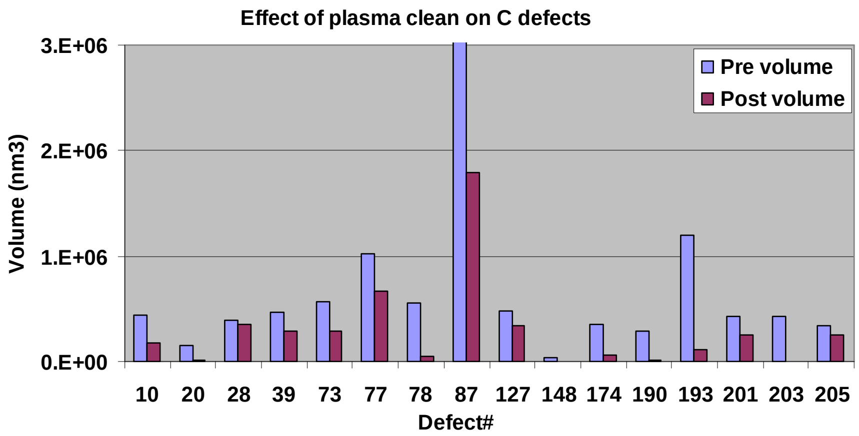
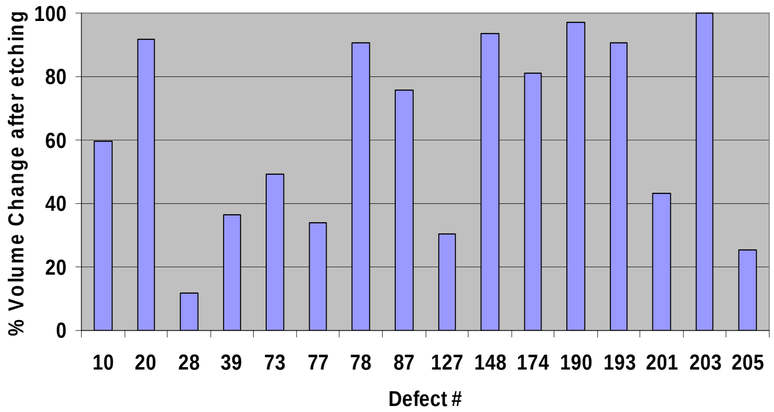


- Ar/O2 (80/20) mixture
- Time=20 min
- Pressure=250mT
- Power=20W





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Cleaning with Hydrogen

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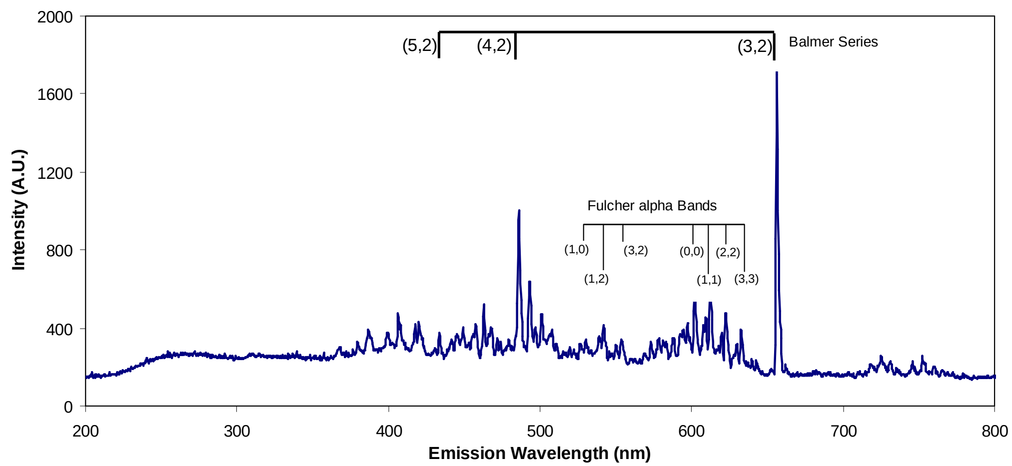

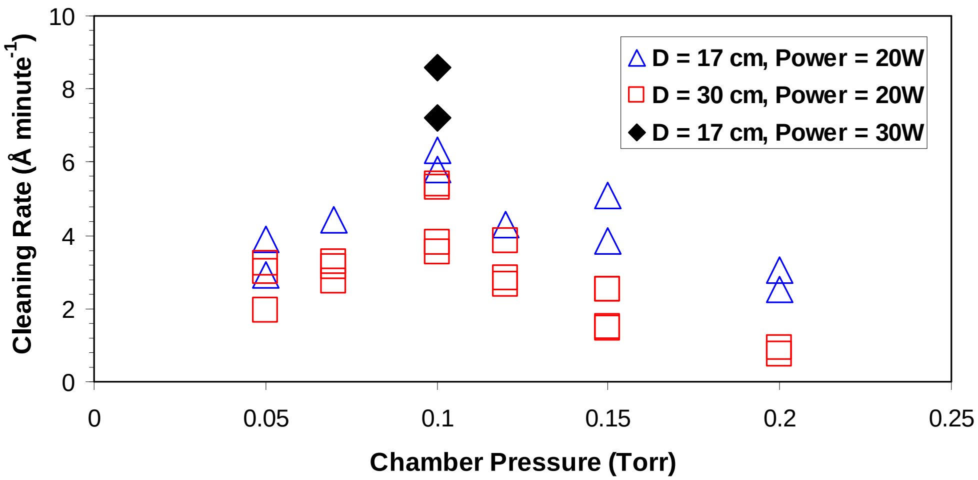

Emission Spectra:

- Pressure=100 mTorr
- Power=20W.
- The first three Balmer hydrogen transitions are seen in the spectrum, along with the Fulcher alpha bands
- Transitions due to N_2, N_2^+, OH, O, or NO are not seen

Cleaning Rates

- Data taken using Quartz Crystal Microbalances (QCMs) coated with a thin layer (10-50 nm) of hydrocarbon contamination (pump oil).
- Maximum rate at 0.1 Torr

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Cleaning with Hydrogen

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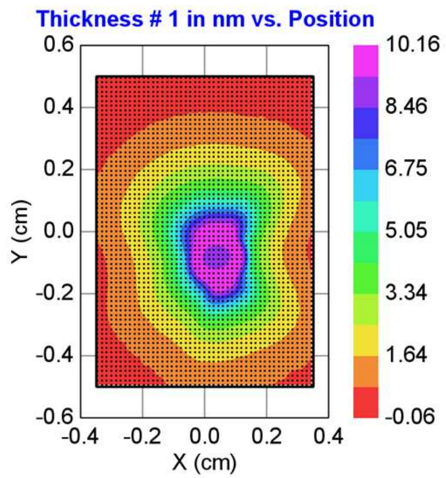
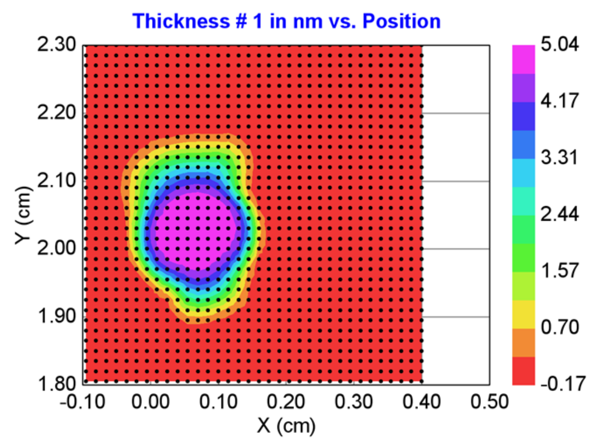
SPOT 1



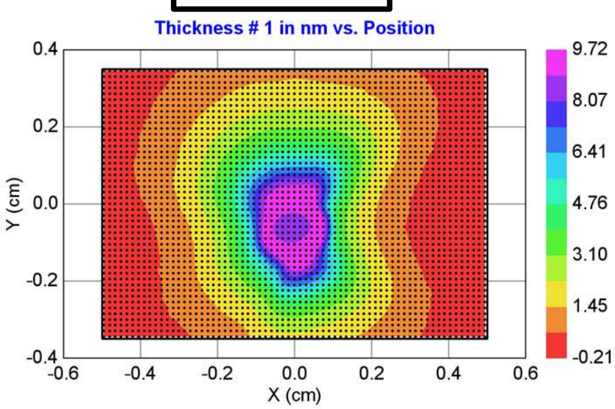
Resist contaminated sample
4 Hours cleaning
20 W
0.1 Torr

5 nm of cleaning in 4 hours

SPOT 1



SPOT 2



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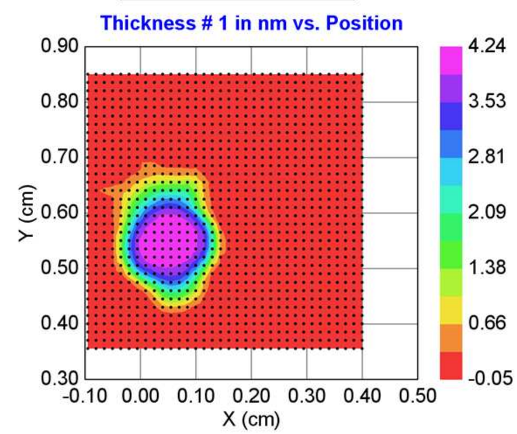
SPOT 2



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New Evactron System for EUV Applications

6/24/2011

XEI will introduce a new system for end users and tool manufacturers in EUV Lithography. This system has been specifically developed to address EUV related cleaning challenges in high vacuum and clean room environments.

- Higher power RF generator (30 watts)
- Standard unit is used with hydrogen for oxygen sensitive cap layers
- Optional plasma source for use with oxygen for silicon-capped multi-layers and substrates
- Clean room compatible
- Contamination free operation
- Desktop or rack mounted configurations available

SUMMARY

- Remote Plasma Cleaning with oxygen-containing gas has been shown to be effective in cleaning EUV optics and substrates.
  - Rates up to 0.85 nm/min with room air 25 cm away
  - Demonstrated cleaning results from external groups (CXRO, CNSE, and SEMATECH)
- Cleaning with hydrogen by remote plasma cleaning has been demonstrated.

FUTURE WORK

- Continued work testing hydrogen to clean EUV components
- Development and testing of higher power sources to improve cleaning efficiency
- Research into working with plasma at lower pressures
- Development and testing of EUV specific system for ultraclean, high vacuum systems

Thank you

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Any Questions ?

Evactron De-Contaminator

Plasma Radical Source (PRS) includes

- KF40 or CF275 fitting
- Valve assembly for metered flow of gas
- Pressure sensor
- RF impedance matching network
- Unique, patented RF electrode (not seen)

Controller includes

- Microprocessor control of PRS
- Compact 13.56 MHz RF generator
- 110-240 V, 50-60 Hz VAC
- External control with RS 232 serial connection – USB dongle available