



Tooling to measure EUV resist outgassing and witness plate contamination

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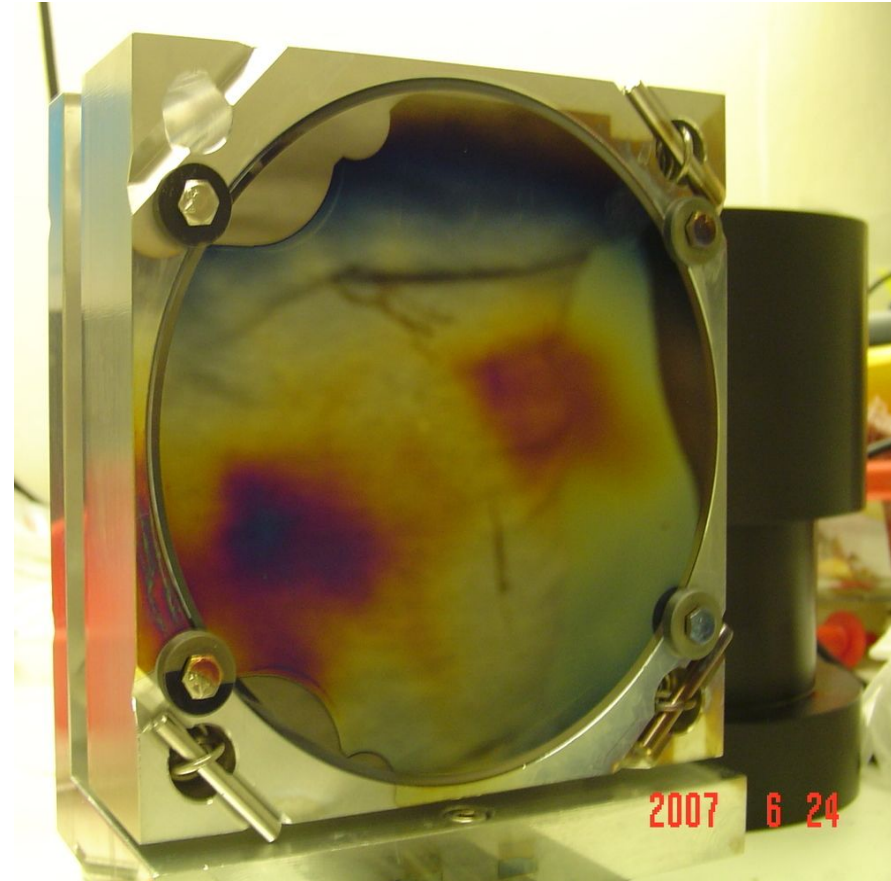


How to contaminate optics

- Deposit contaminant
 - Hydrocarbons
 - High partial pressure
 - Bad vacuum
- Expose to radiation
 - Photons
 - Electrons

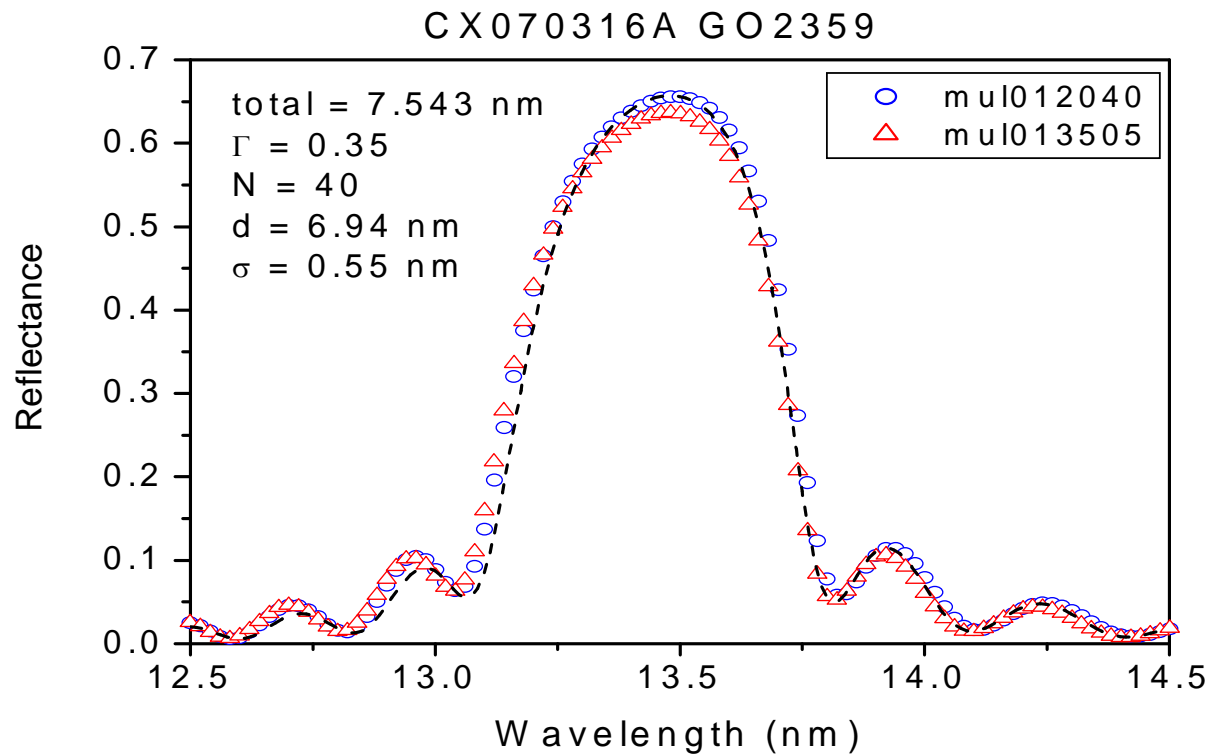
Contaminated ML Mirror

- Energetic source
 - Damaged Zr filter
 - Bad vacuum (10^{-3} mbar)
 - Carbon tape
- Directly illuminated the ML mirror for several hours
 - Accidentally illuminated the carbon tape



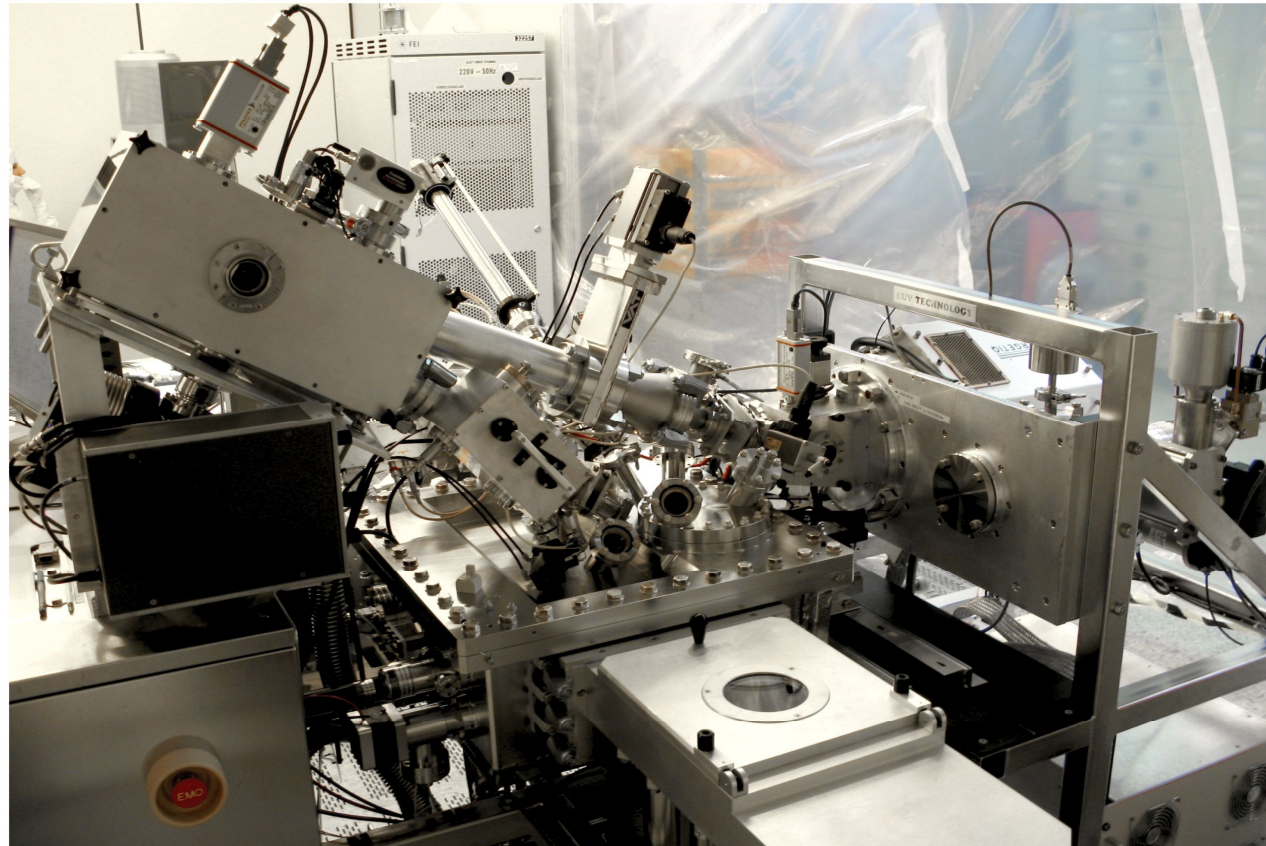


Reflectivity measurements after cleaning, ALS July 1, 2007: Compared with before contaminating the optics



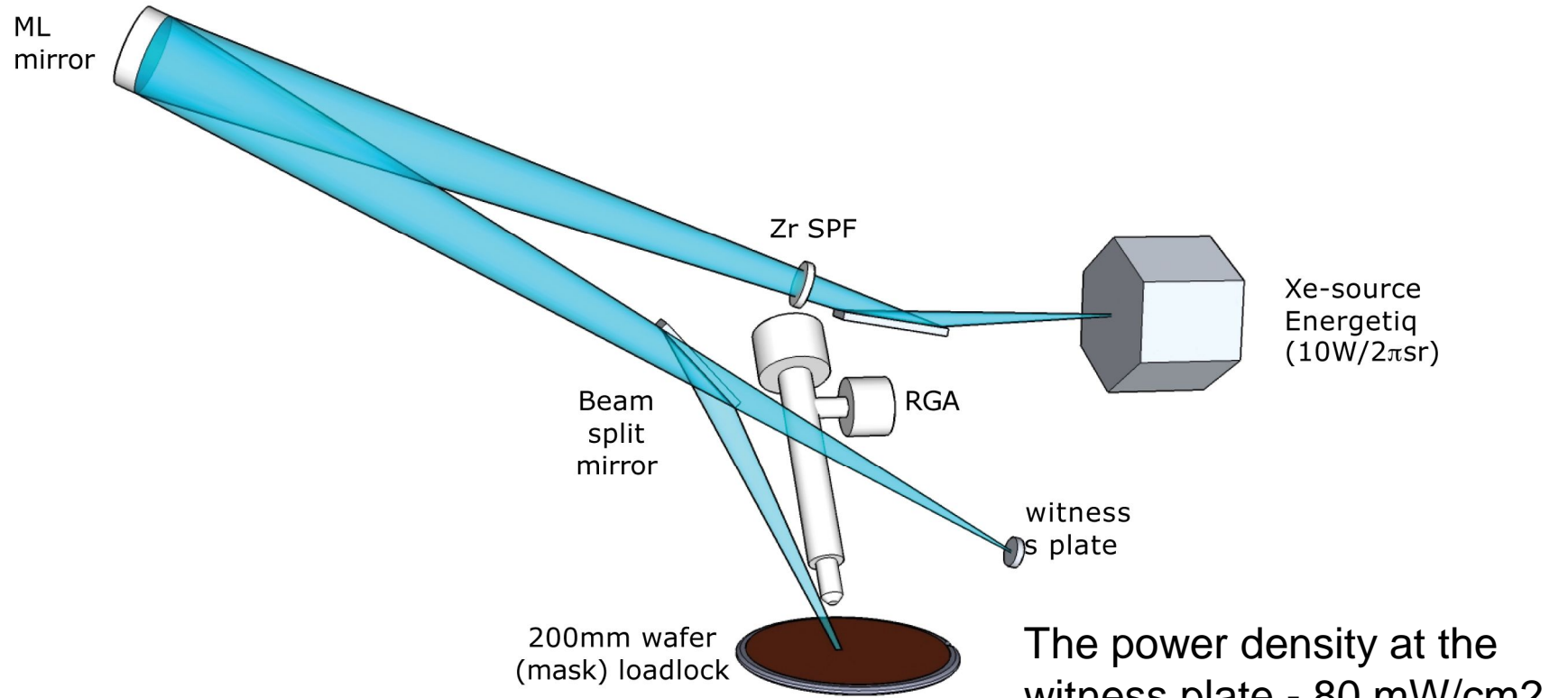


EUV Resist and Outgassing Prototype tool delivered to IMEC in October 2008: ADT guidelines





Schematic Diagram of EUV RER 1314 for ADT guidelines

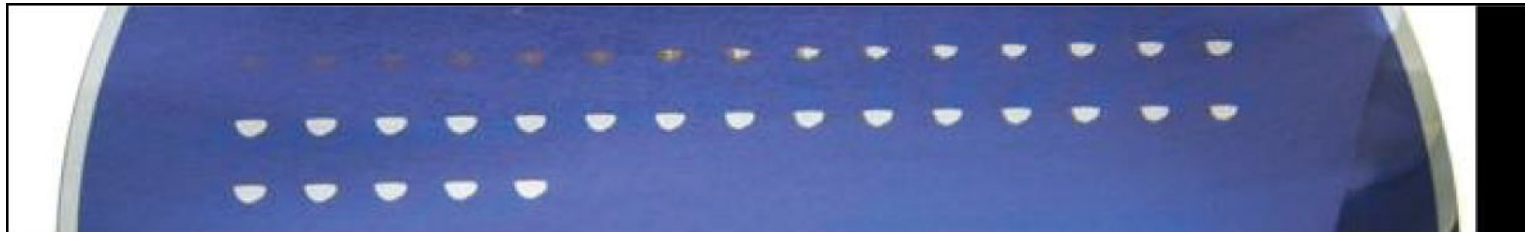


Power density at the resist - 5 mW/cm².

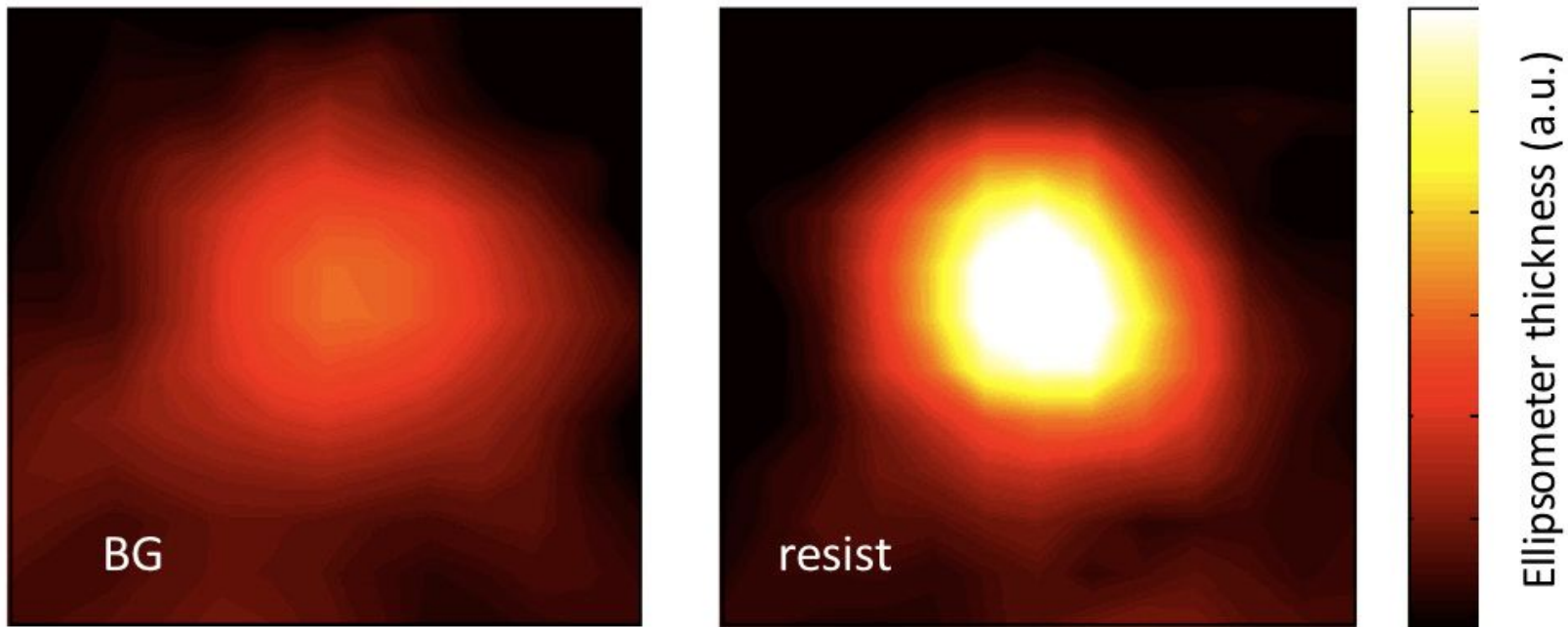
The power density at the witness plate - 80 mW/cm².



Dose Snake

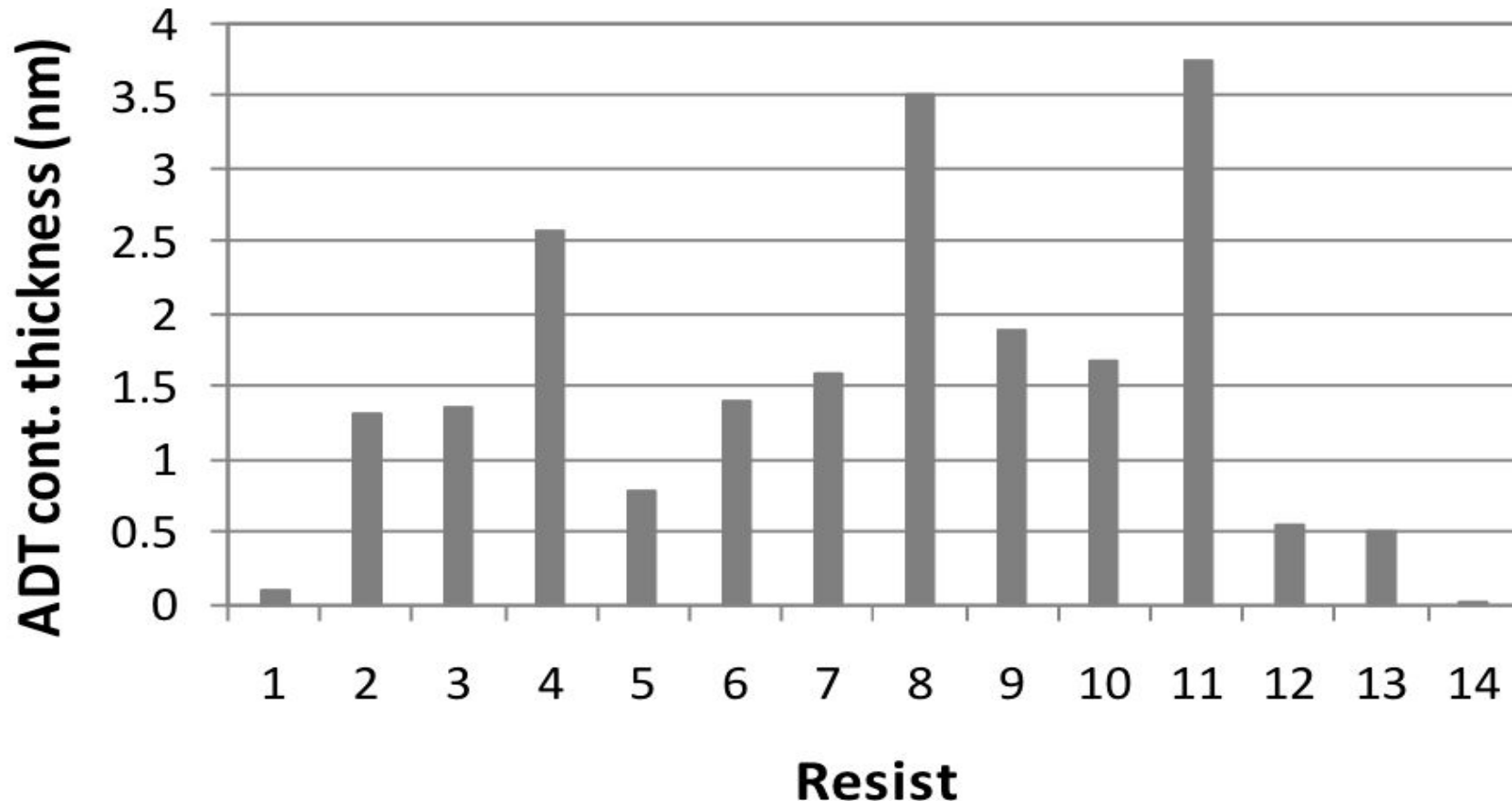


Example of WS test result using in-band EUV photon excitation as measured with ellipsometry





Overview of WS contamination test results obtained in the last half year at IMEC as part of resist outgassing qualification towards ASML ADT



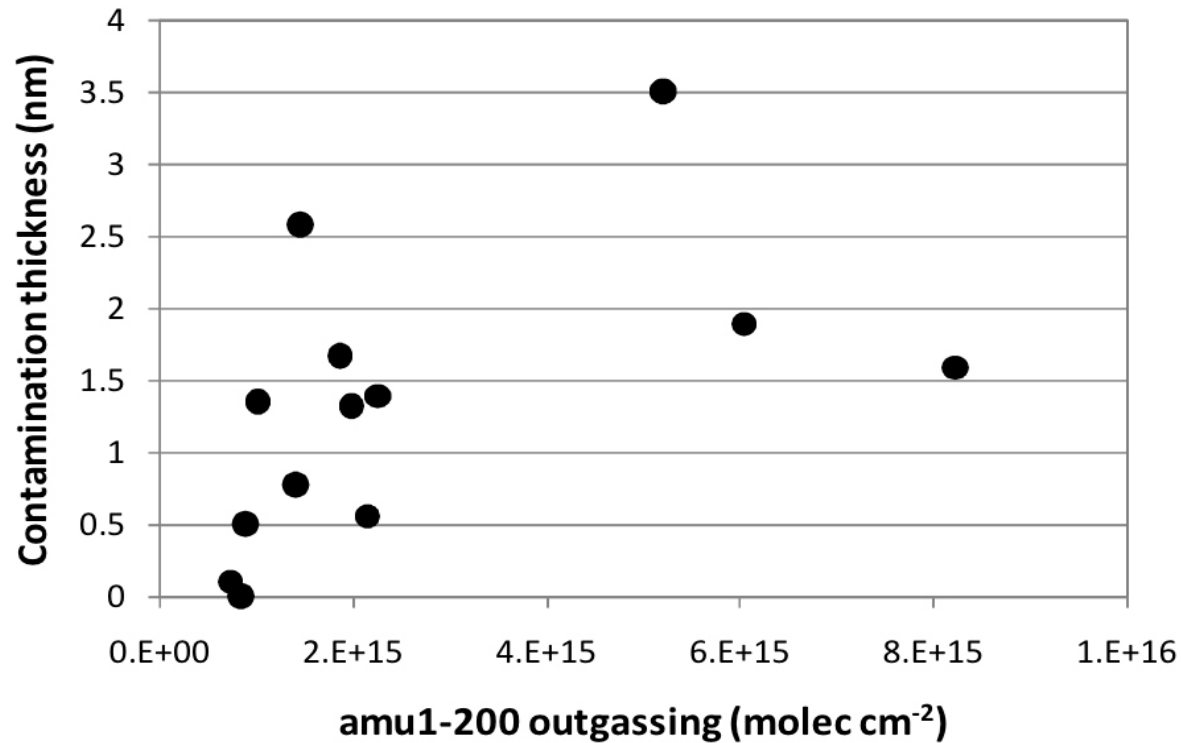
Courtesy of Pollentier *et al.*

IEUVI Resist TWG, Kobe Japan

October 17, 2010

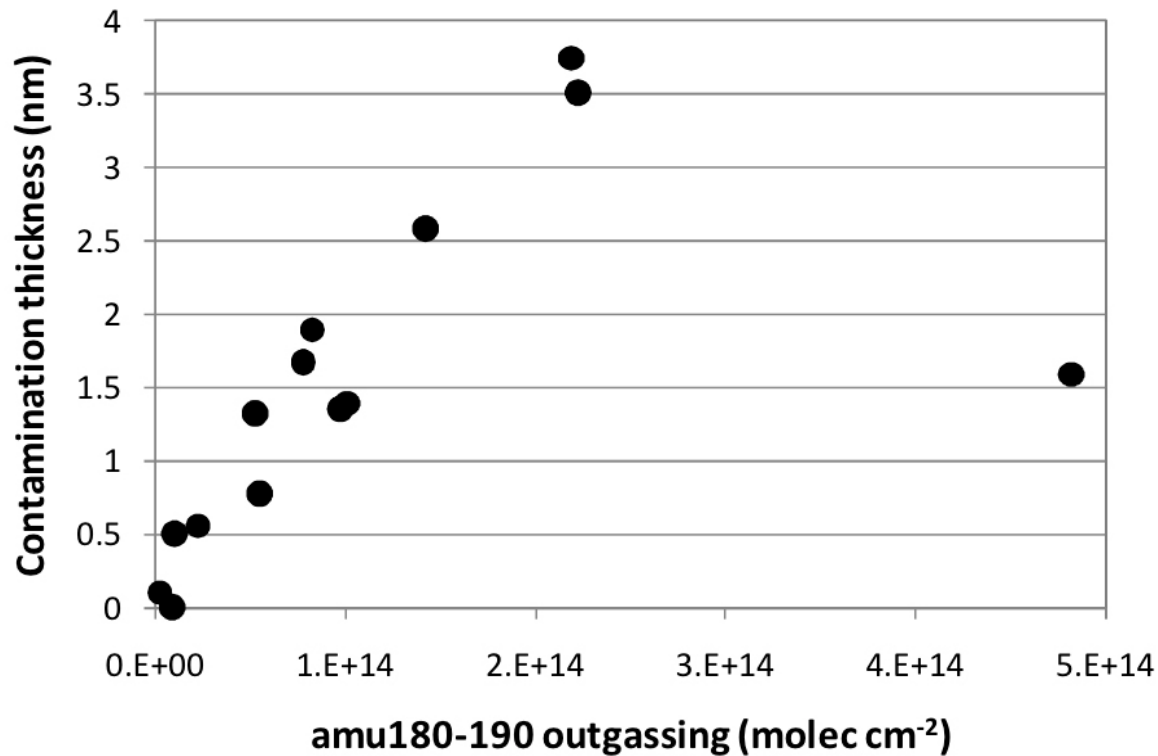
EUV Technology Business Sensitive Information

Contamination Vs. Total outgassing (All species, i.e. amu 1-200)



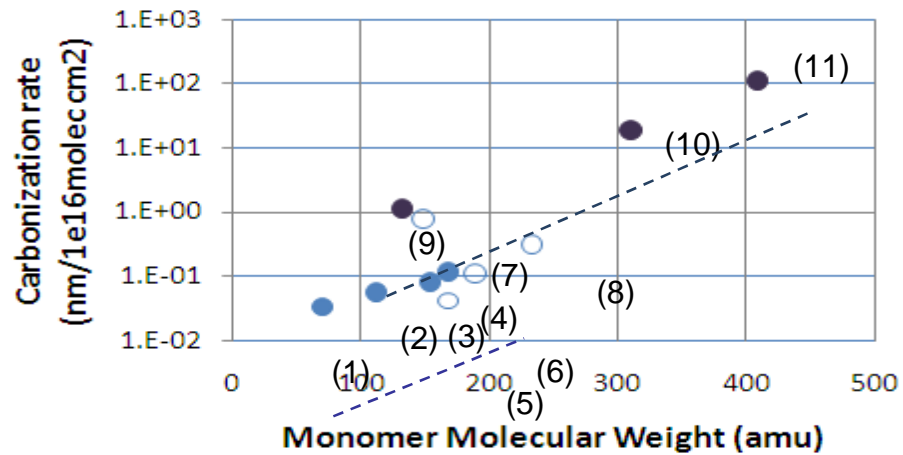
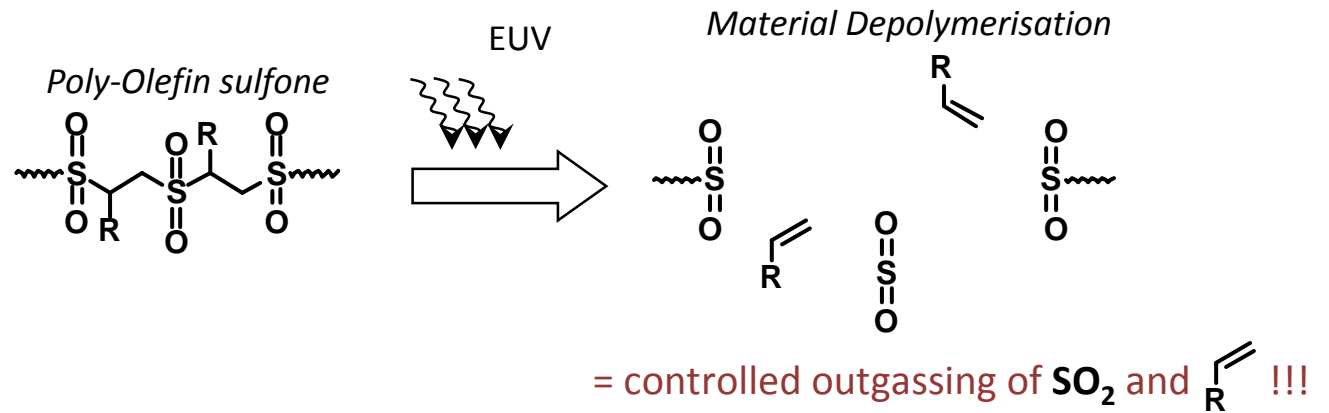
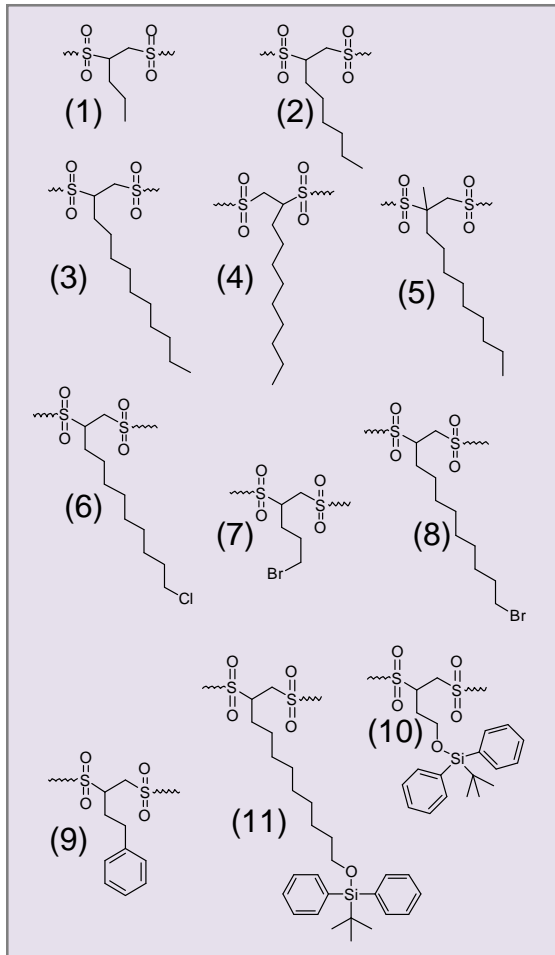
Contamination is not correlating with total outgassing

Contamination Vs. “PAG cation out-gassing” (amu 180-190)



PAG cation fragment plays an important role in the contamination for many photoresists from multiple suppliers.

POLY(OLEFIN SULFONE)S - A MATERIALS PLATFORM FOR STUDYING RESIST DERIVED CONTAMINATION



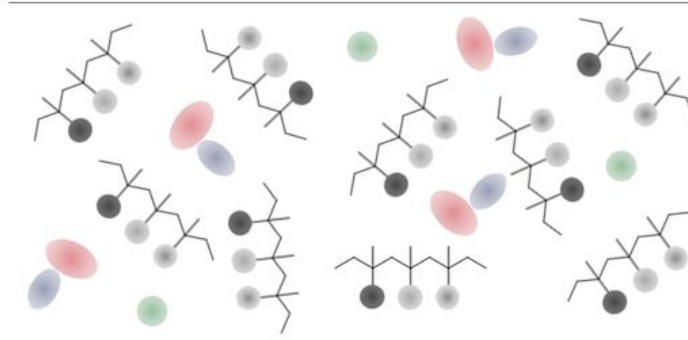
Poster RE-2 (K. Lawrie)

Aryl group materials have one order of magnitude higher carbonization rate than alkyl containing groups of similar MW

OUTGASSING AND WS CONTAMINATION TESTING ON VARIOUS RESIST MATERIALS

For chemically amplified resists the **PAG-cation** is found key in outgassing and contamination, but also other species play a role

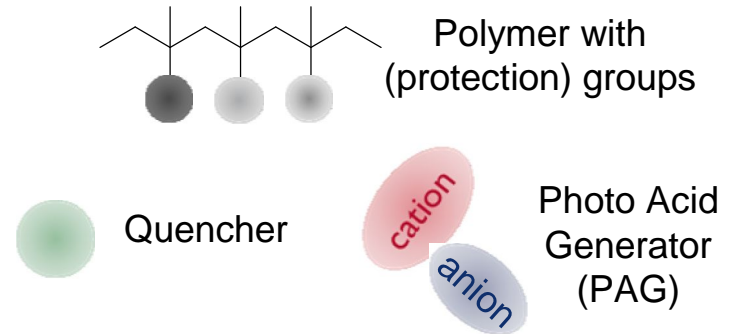
PAG blended EUV resist



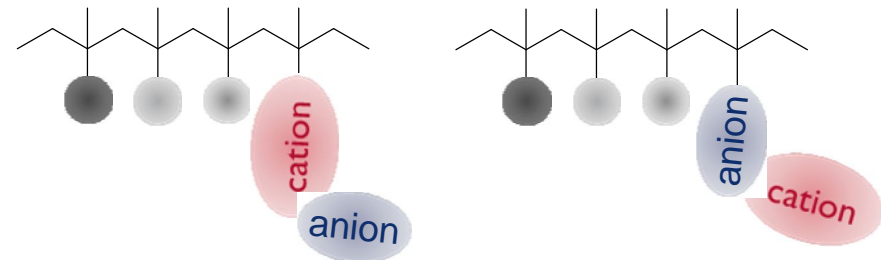
WS contamination thickness is dependent on PAG MW, chemistry, loading, ...

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PAG-bound EUV resist



Similar WS contamination thickness found for cation and anion bound PAG (other species play a role !)

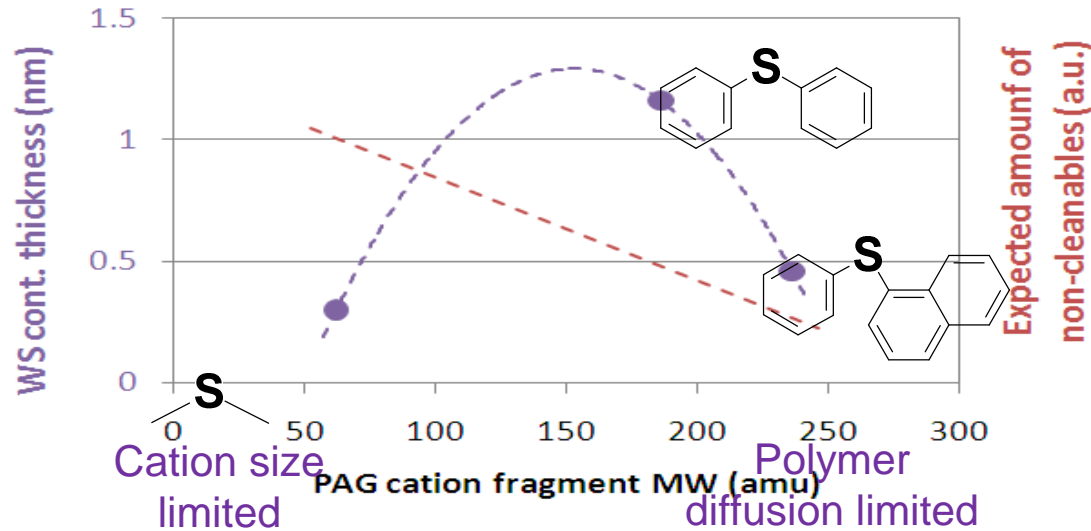
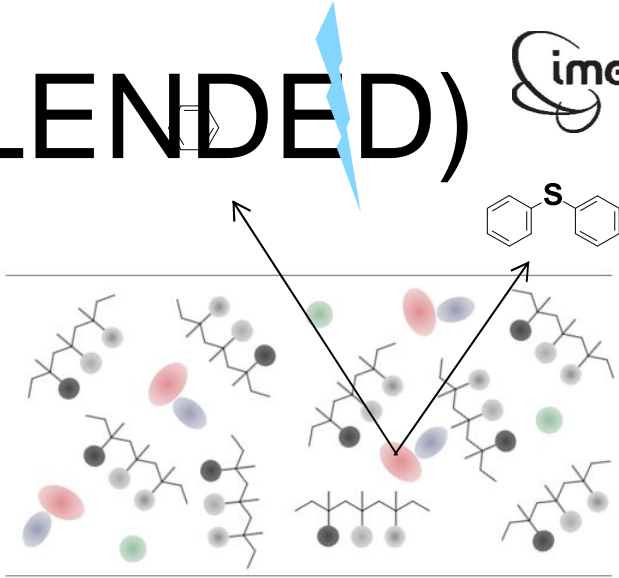
Poster RE-

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PAG TYPE (BLENDED)

PAG
anion
cation

Several PAG cations are tested towards WS contamination



IVAN POLLENTIER

Both small PAG cations as very heavy PAG cations give lower WS contamination, however it is expected that for S-containing cations the high-MW will result in less non-cleanable contamination

Poster RE-13



Highlights

- Operating for about 18 months
- Use EUV in-band excitation.
- Very good uptime (reliable)
- Extremely easy to use
- New results
- Not designed for NXE platform.



RER-300-PEX



Design Philosophy

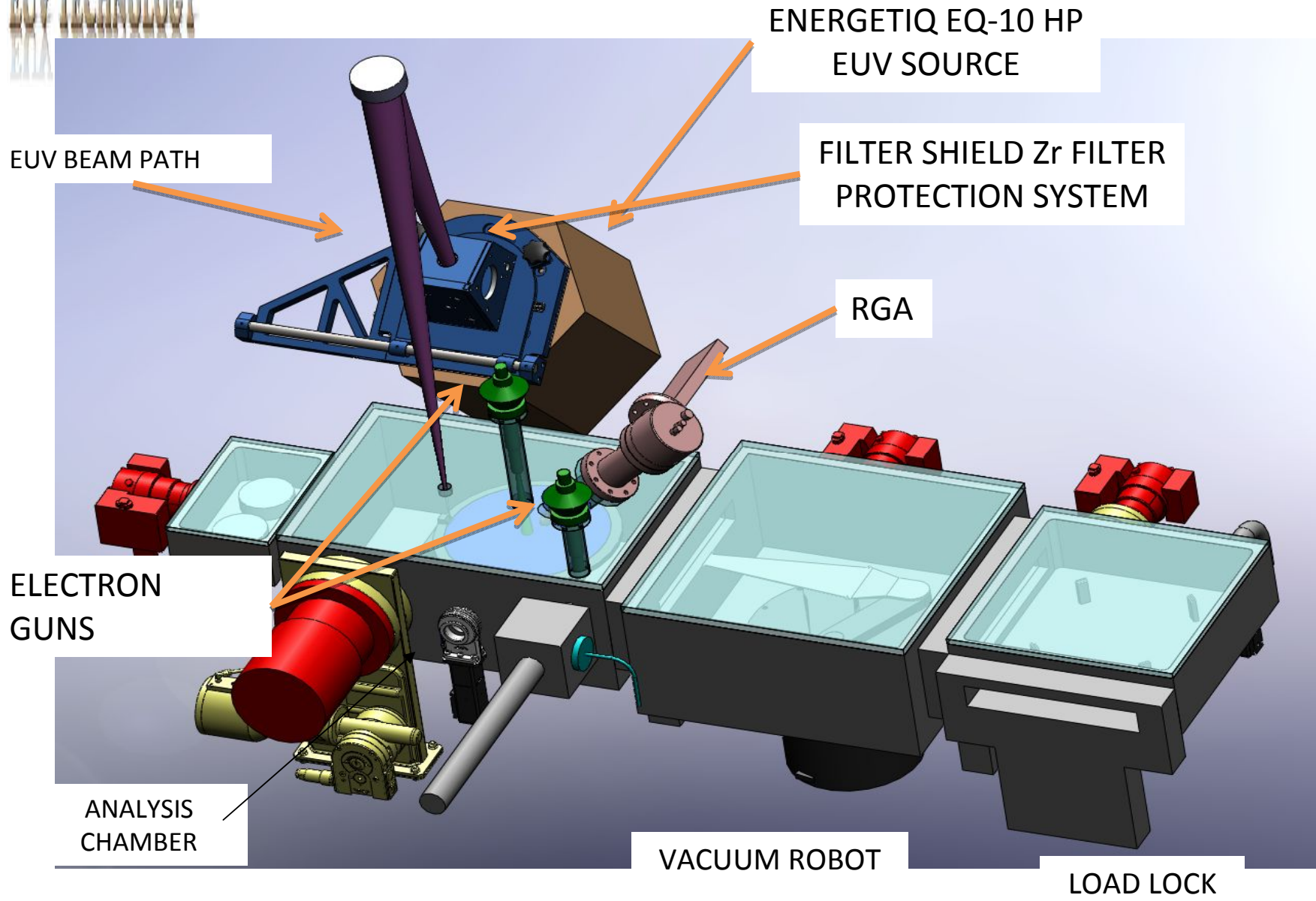
- Based on our previous model of resist outgassing and contamination measuring tool delivered to IMEC in 2008 (Model No. EUV-RER1314; Patent Pending)
- Based on two ASML (confidential) guidelines for NXE scanners.
 - Photon based
 - E-gun based



Sources

- Model No. RER300-PEX is equipped with
 - In-band EUV photon excitation source
 - E-beam exposure capabilities to exposes resist coated wafers.

System is designed in such a way that it can be ordered with one mode of operation and field upgraded to add the other option.



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EUV Excitation

- Uses Energetiq EQ-10-HP as the EUV source
- Utilize a novel optical system to provide in-band spectrum of illumination of the resist-coated wafers.
- A minimum intensity of 35 mW/cm² incident on the wafer.

Based on the measurements performed at IMEC using the prototype resist outgassing system developed by EUV Technology about 2 years ago and incorporating system upgrades embodying recent advances in the industry, a typical EUV resist exposure measurement can be performed in about 1 hour.



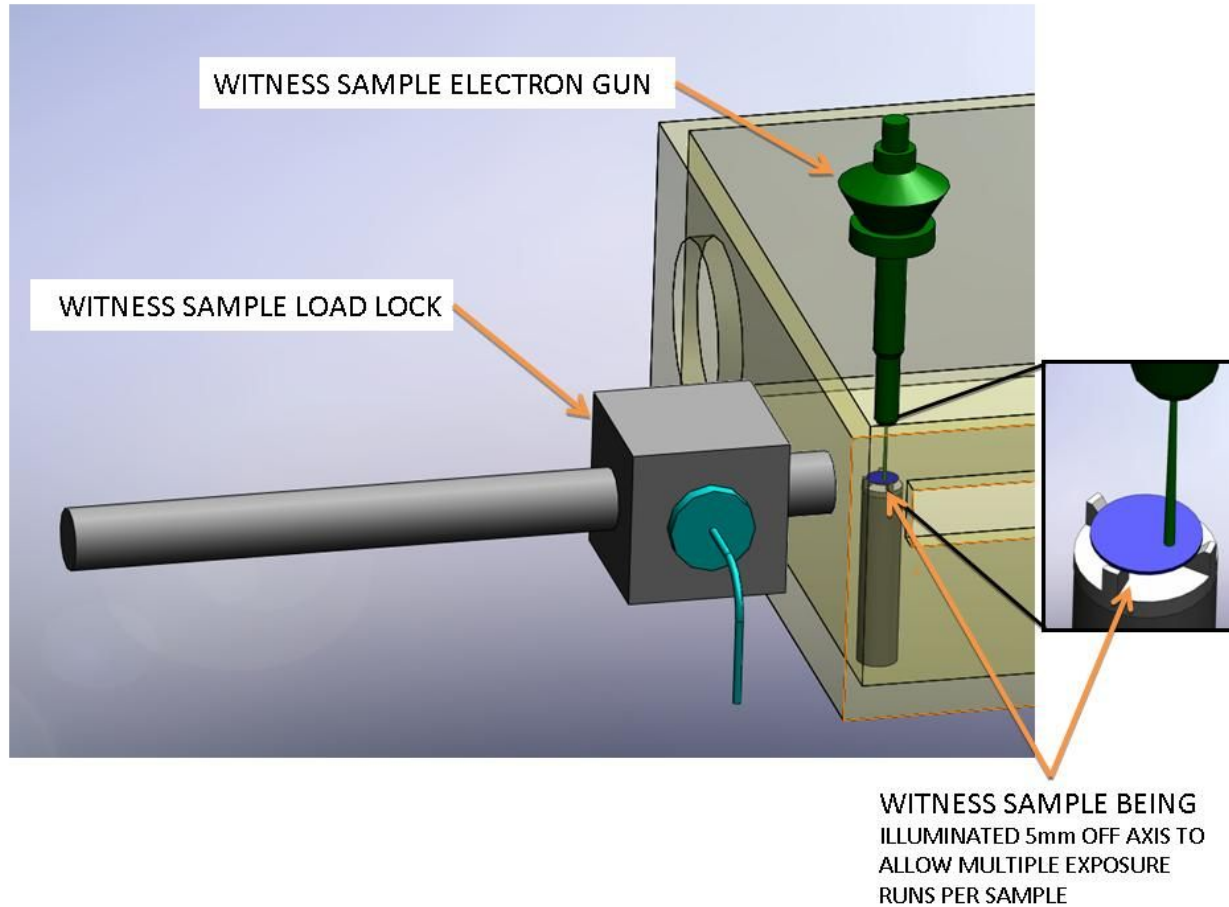
Electron excitation

- An EFG-7F electron gun manufactured by Kimball Physics Inc., is used to expose the resist-coated wafer.
 - The wafer e-gun illuminates a spot approximately 20 mm in diameter on the wafer the resist wafer at 90 degrees to the wafer.
- The stability of the beam currents from this e-gun is better than $\pm 5\%$ over the time of two hours.
 - In addition, only the electrons from the wafer e-gun are allowed to reach the wafer.

This the same e-gun described in the paper presented by I. Pollentier, A-M. Goethals, R. Gronheid, J. Steinhoff, and J. Van Dijk at the SPIE (February 2010).



Witness Plate: 1" Ru coated Si or GaAs wafer or a ML coated (Ru cap) wafer





For salient features and detail description of RER-300-PEX, please visit our poster.



Highlights

- EUV Technology can provide customers with
 - Calibrated multilayer-coated witness samples
 - Collaborate with them to cross calibrate their witness sample contamination results, obtained by ellipsometry, to reflectivity losses using our in-house EUV Reflectometer.
- Construct our tools to meet the NFPA-79 guidelines.
- We have experience in constructing tools
 - SEMI-S2/S8, SEMI-F47 standards, CE certification et
 - SECS protocol



Advantages of using 13.5 nm photons over electrons

- The EUVL stepper uses photons
- True dose to clear exposure.
- Non destructive.
 - Only detect photo-induced decomposition.
- Represent bulk properties.
 - Not sensitive to surface contamination.



Principal team members

Rupert C. Perera

- Ph.D. from University of Hawaii, Honolulu in 1978, and MBA (Management Science) in 2000.
- Ph. D. Thesis: Molecular spectroscopy in ultra soft x-ray (2 -15 nm) region.
 - Prof. Burton Henke: Henke tube; World's First selective EUV source

James Underwood

- Ph. D. in Physics from the University of Leicester, England
- A pioneer in x-ray and EUV optics
 - In 1983 co-founded the Center for X-ray Optics at LBNL, pioneered the EUVL program.



Thank You