Resist Outgas Metrology Update

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EUVL Optics Contamination TWG

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An alternative metrology to reflectometry has been tested

- Ten resists have been tested for resist outgas contamination of witness samples.
- Reflectometry results
  - All 10 resists are well within the 2% ΔR/R ADT spec
    - ΔR/R < 0.2% (accuracy of reflectometry is ~±0.015%)
    - Results on a per wafer basis are similar to the back ground chamber results
- Several of the witness samples have also been measured with ellipsometry and XPS, and results correlate to the reflectometry data.
- **Conclusion**: XPS and ellipsometry can be used for witness sample metrology instead of reflectometry in the ASML qualification

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Ellipsometry measurement density is similar to the reflectivity loss measurements

Scan over the whole sample:

- 1 mm grid (365 points) in ca. done in 30 minutes
- Each of the 365 points is measured 30 times, mean Δ (amplitude ration from reflection) and Ψ (phase shift) are reported
  - Uncertainty is $\Delta \pm 0.1°$, $\Psi \pm 0.03°$ due to positioning & alignment (offset error)
- Angle of Incidence 70º
- Automatic fitting for carbon layer on Ru witness sample over surface scan

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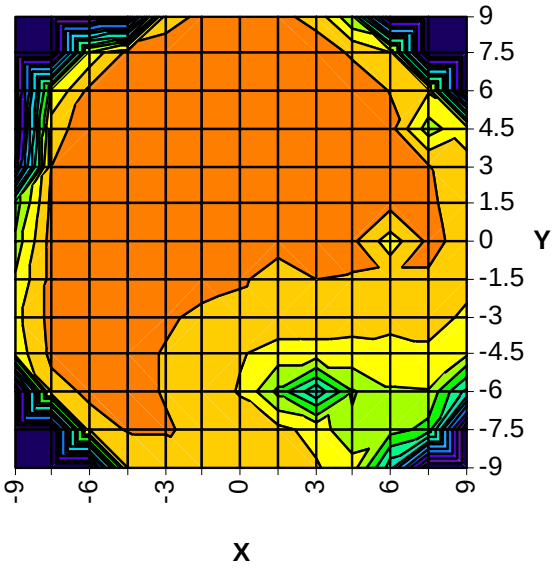
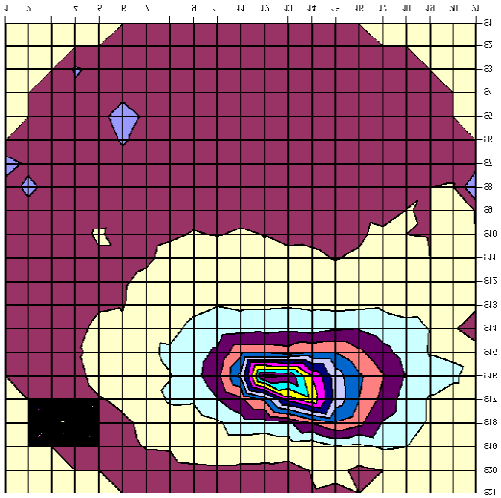
Sample ellipsometry results show similar “fingerprint” as reflectivity map



Reflectivity map



Ellipsometry map

Stage tilt correction has been applied to the ellipsometry map

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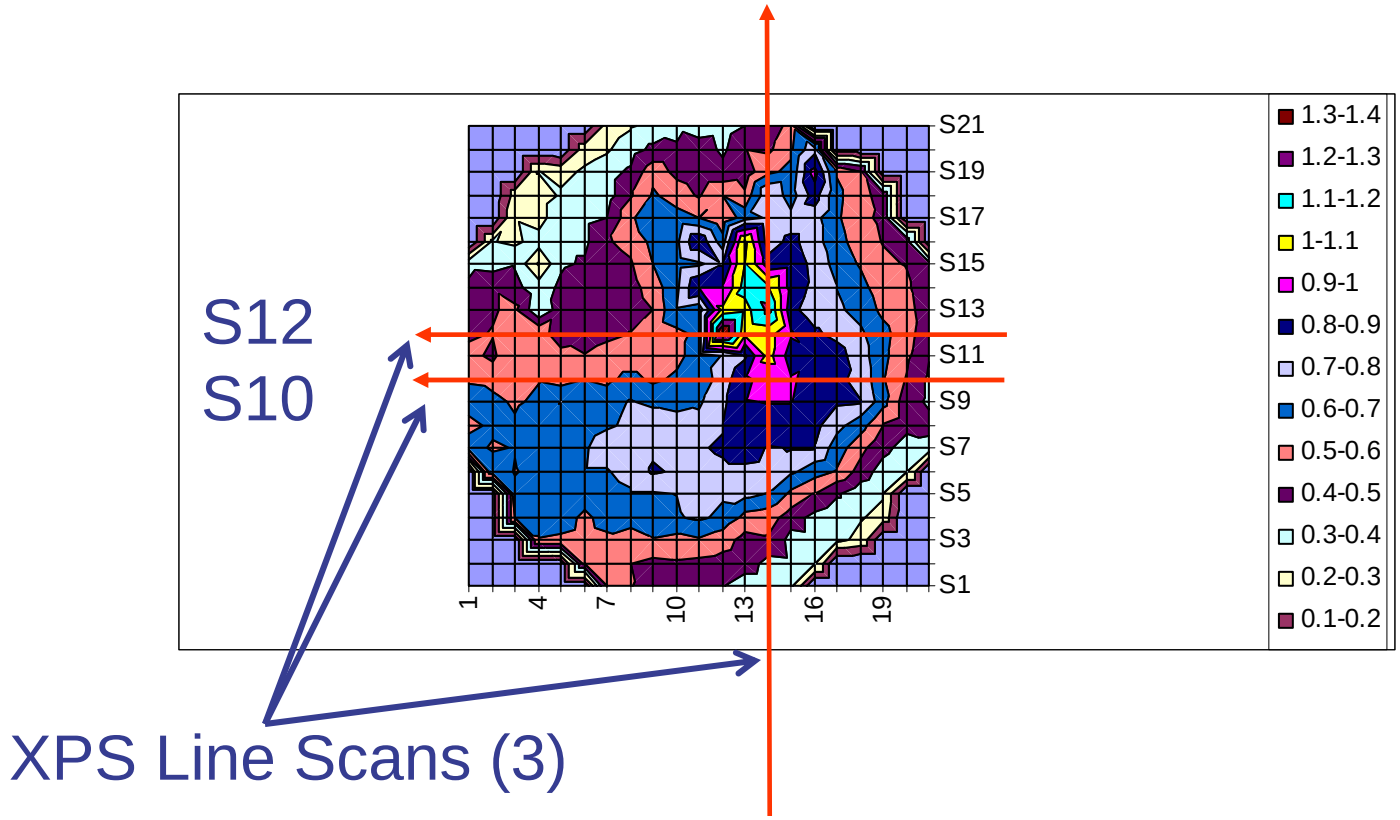
XPS was used to confirm the content of the film thickness, but only line scans can be used

Ellipsometry results of witness sample



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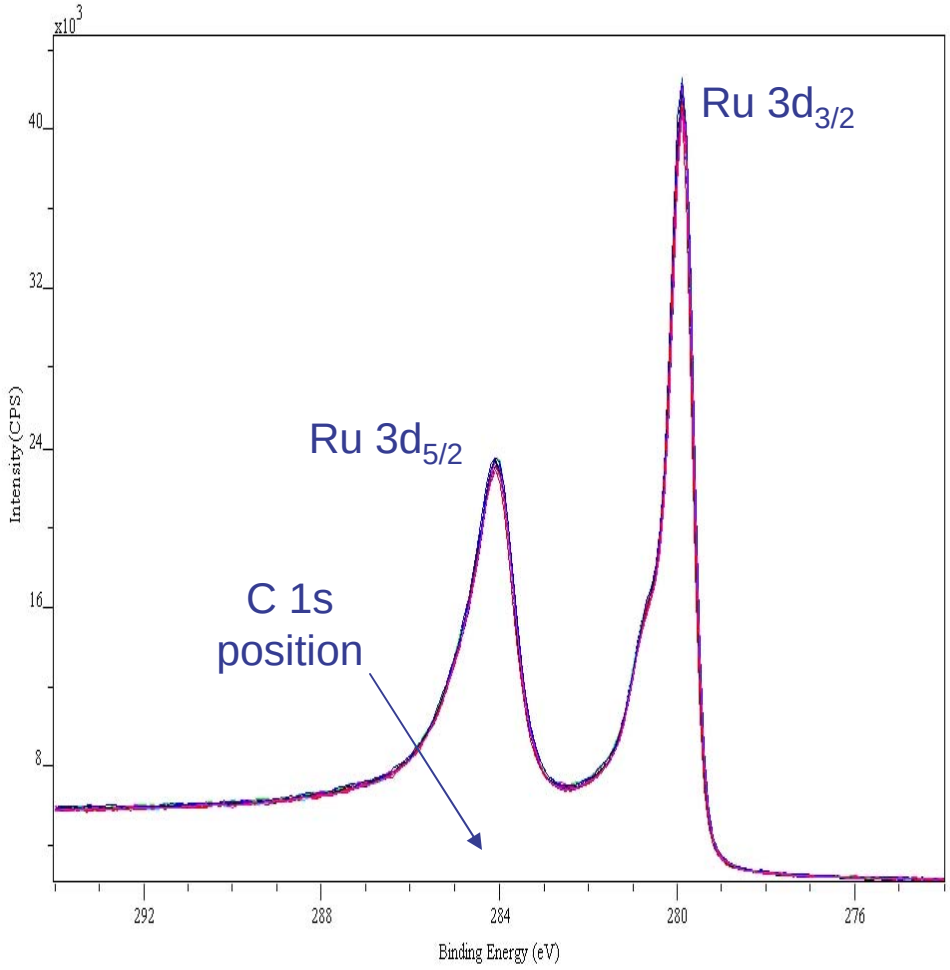
XPS Measurements



- 2 Ru peaks for the main Ru line due to spin-orbital-splitting
- Overlap with main C line
- Measurement gives total “Ru 3d” signal and ratio between Ru $3d_{3/2}$ and Ru $3d_{5/2}$/ C 1s

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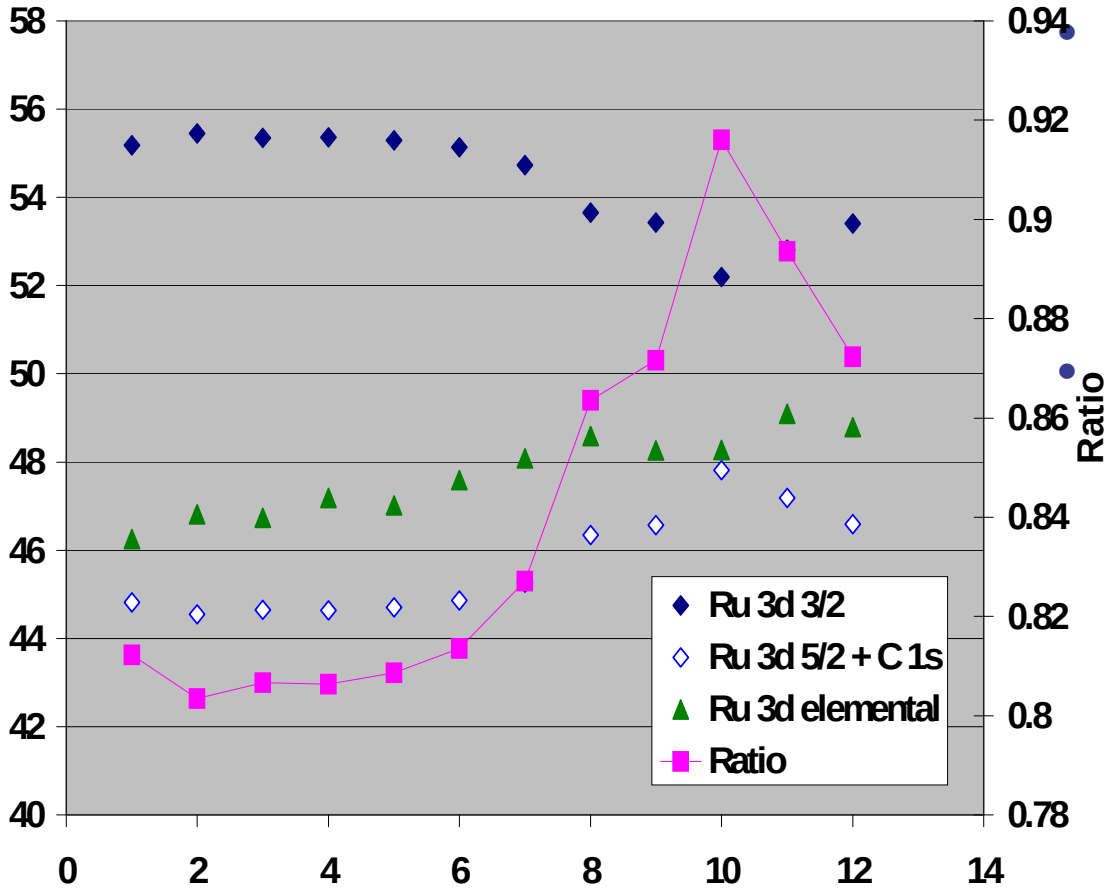
The changing ratio of Ru3d3/2 to Ru3d5/2 indicates more carbon on the surface



S12 scan

- Total Ru signal decreases with increasing C film thickness due to lower sensitivity of C compared to Ru
- Ratio between “Ru” peaks shifts towards Ru $3d_{5/2}$/ C 1s with increasing C film thickness → ratio can be taken as a relative measurement of C film thickness

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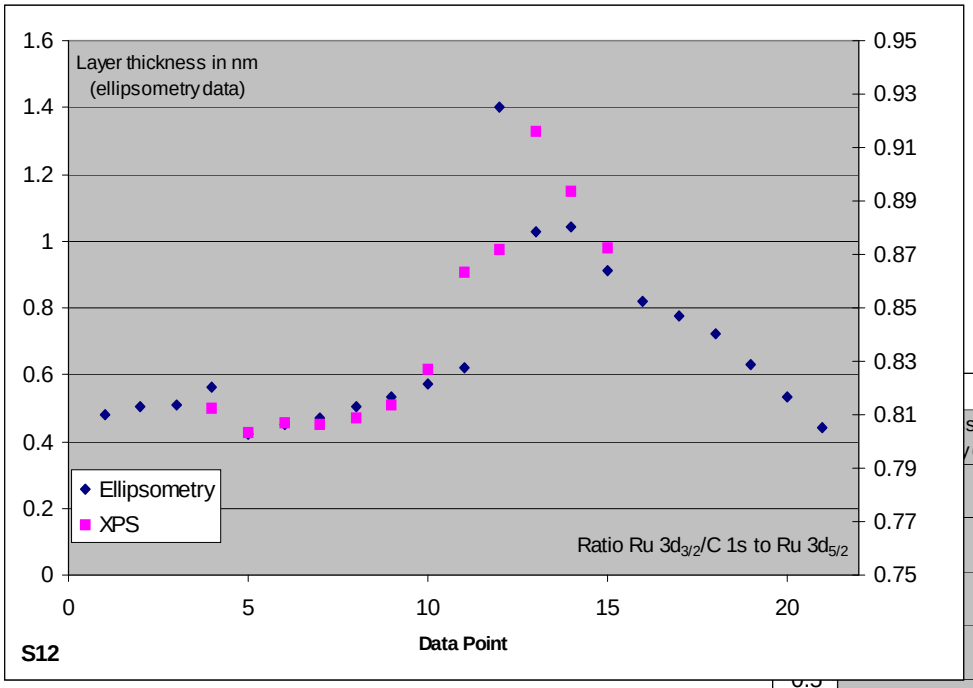
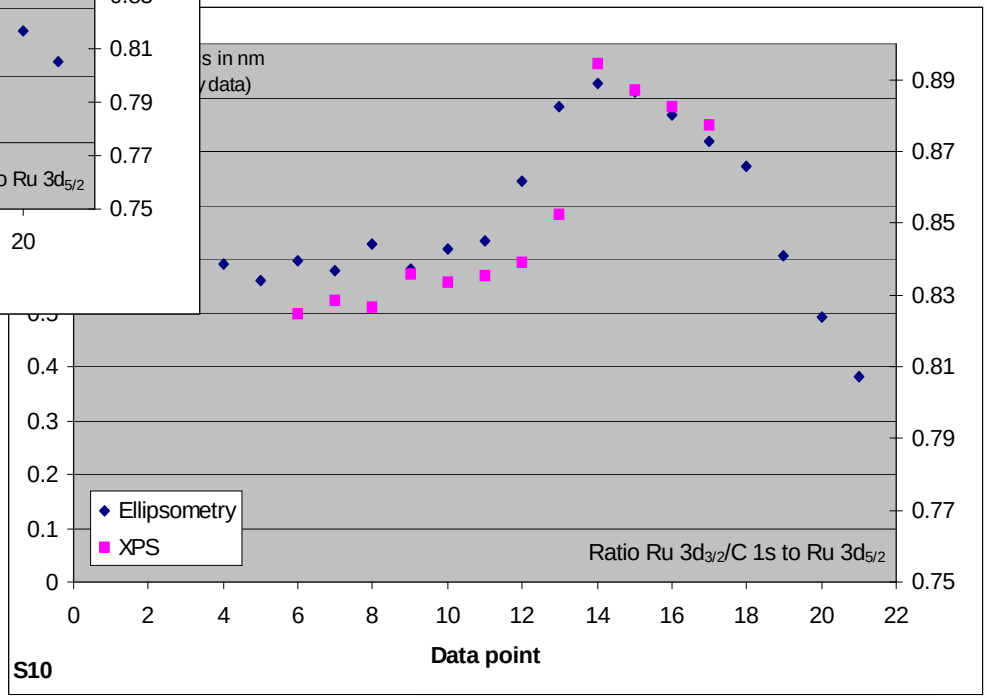
Ellipsometry data correlates to XPS line scans



S12

S10



- No curve fitting of XPS data
- Correction applied for carbon shielding of the Ru3d3/2 + C1s signal (determined by the change in ratio (previous graph))

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XPS data verifies mostly carbon at the witness sample surface since there are no other strong peaks

- XPS measurements have been performed in the center of the witness samples (recently tested resists only)

C 1s

	Na 1s	F 1s	O 1s	Ru 3d	Substrate
Lab witness	0.43	0.00	28.14	47.23	24.20
Resist Sample A	0.08	0.53	28.77	46.95	24.21
Resist Sample B	0.30	0.12	28.16	47.17	27.26
Resist Sample C	0.32	0.49	28.00	47.27	23.93
Resist Sample D	0.20	0.00	28.66	47.34	23.80
Resist Sample E	0.26	0.59	27.56	48.23	23.36

- Ru3d3/2 overlaps with C1s
- Ru3d is the sum of Ru3d3/2, Ru3d5/2, and C1s

- Contamination films are likely carbon since no other peaks show except for those from the witness sample materials and oxidation of the Ru

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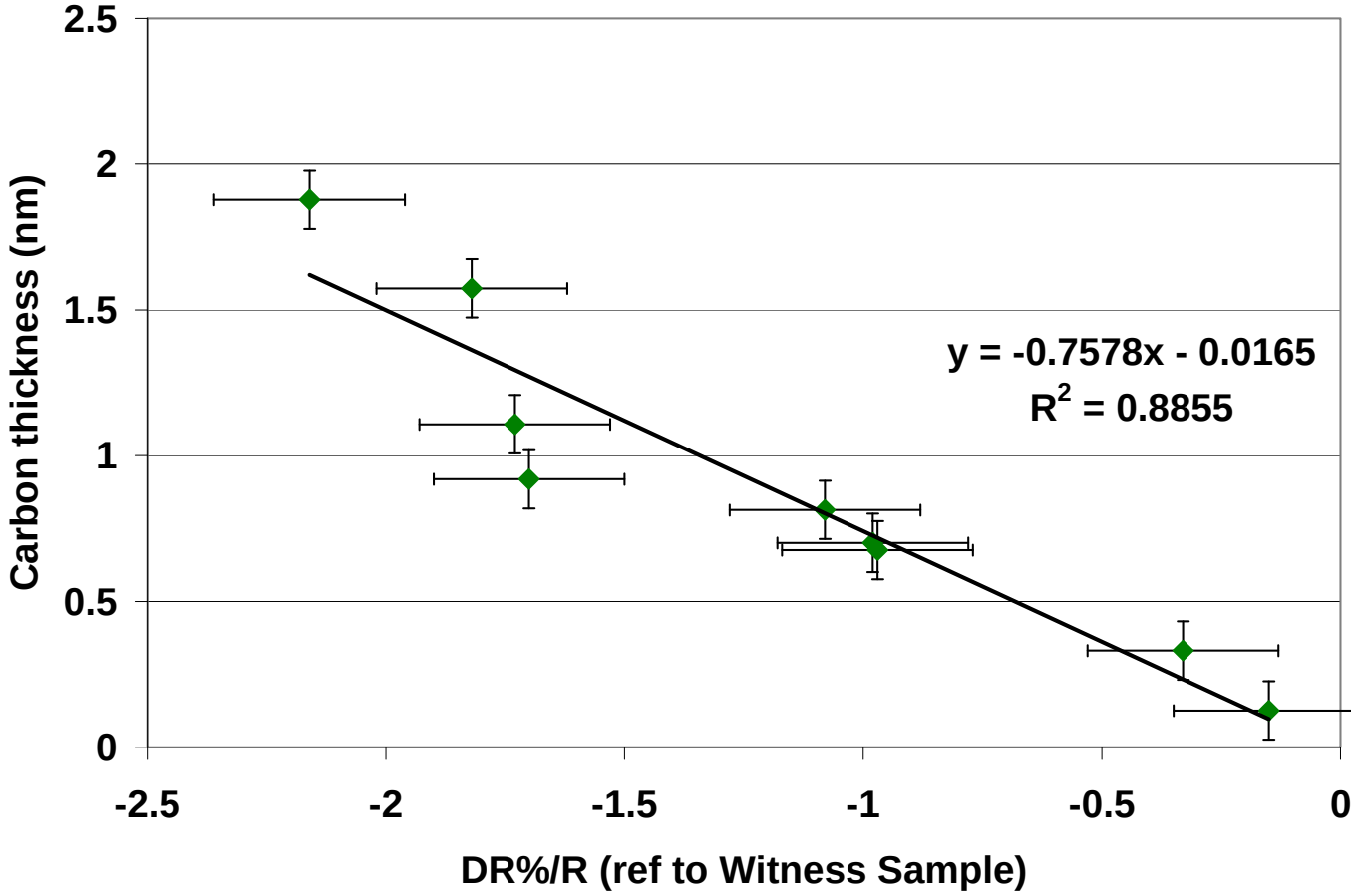
Good correlation between reflectivity loss and carbon thickness



- Sensitivity is ~1.3% reflectivity loss/nm carbon growth
- Each point is a separate sample

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Summary

- Photon based qualification is still preferred by ASML, and cycle time (and cost) for testing are improved with the change in metrology
- Ellipsometry with XPS have been shown to correlate to reflectivity loss and is the new baseline metrology
  - Both measurements are needed
  - XPS confirms mostly carbon and matches ellipsometry for film thickness profile
  - Ellipsometry establishes film thickness
- Next Steps – collaboration:
  Try to correlate outgassing, measured with gas analysis technique, to mirror contamination
  - E-gun based set-up with GC-MS, witness samples with ellipsometry and XPS
  - Use similar/same witness “mirrors”

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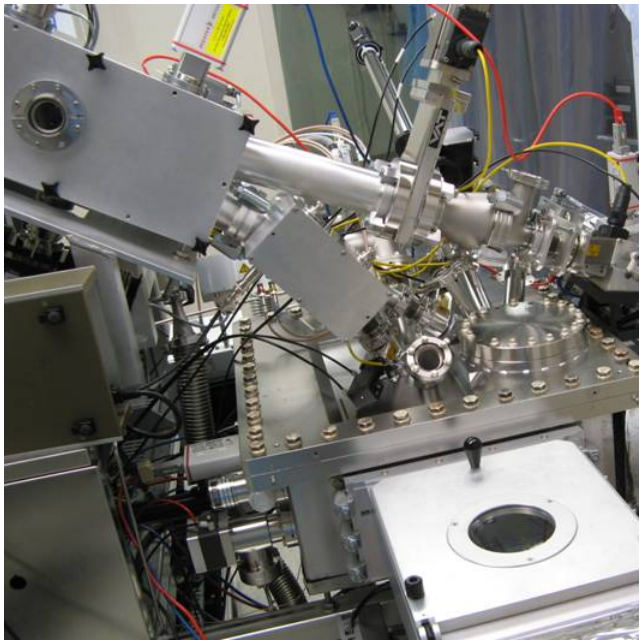
IMEC collaboration on outgassing



EUV Technology outgassing set-up shipped to IMEC (26 Sep '08)

- Hardware characteristics
  - EUV exposure using Energetiq EQ-10R source (10W/2πsr)
  - Vacuum ~1e-8mbar, incl. plasma clean
  - Pfeiffer RGA 1-512amu
  - Loadlock for insertion of 200mm resist coated wafers
  - Loadlock for insertion of witness plates
- Tool objective
  - RGA resist outgassing measurement prior to use on ASML ADT
  - Fundamental understanding of the relationship between witness plate contamination and RGA outgassing spectrum
  - Collaboration with ASML on resist outgassing qualification procedures