



ASML

Resist Outgas Metrology Update

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EUVL Optics Contamination TWG

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An alternative metrology to reflectometry has been tested

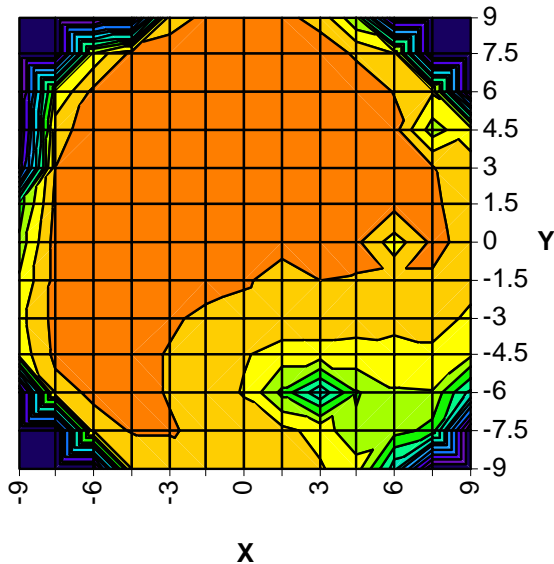
- Ten resists have been tested for resist outgas contamination of witness samples.
- Reflectometry results
 - All 10 resists are well within the 2% $\Delta R/R$ ADT spec
 - $\Delta R/R < 0.2\%$ (accuracy of reflectometry is $\sim \pm 0.015\%$)
 - Results on a per wafer basis are similar to the back ground 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

Ellipsometry measurement density is similar to the reflectivity loss measurements

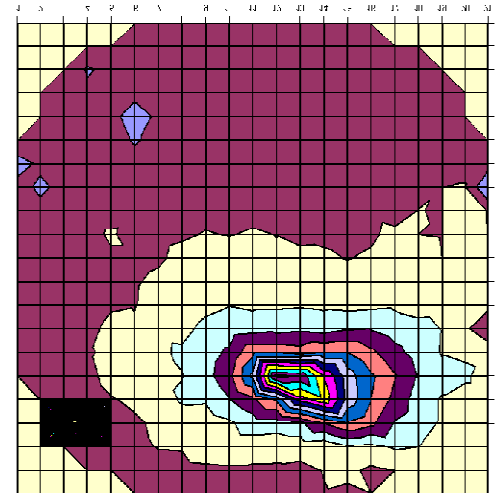
Scan over the whole sample:

- 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 $\Delta \pm 0.1^\circ$, $\Psi \pm 0.03^\circ$ due to positioning & alignment (offset error)
- Angle of Incidence 70°
- Automatic fitting for carbon layer on Ru witness sample over surface scan

Sample ellipsometry results show similar “fingerprint” as reflectivity map



Reflectivity map

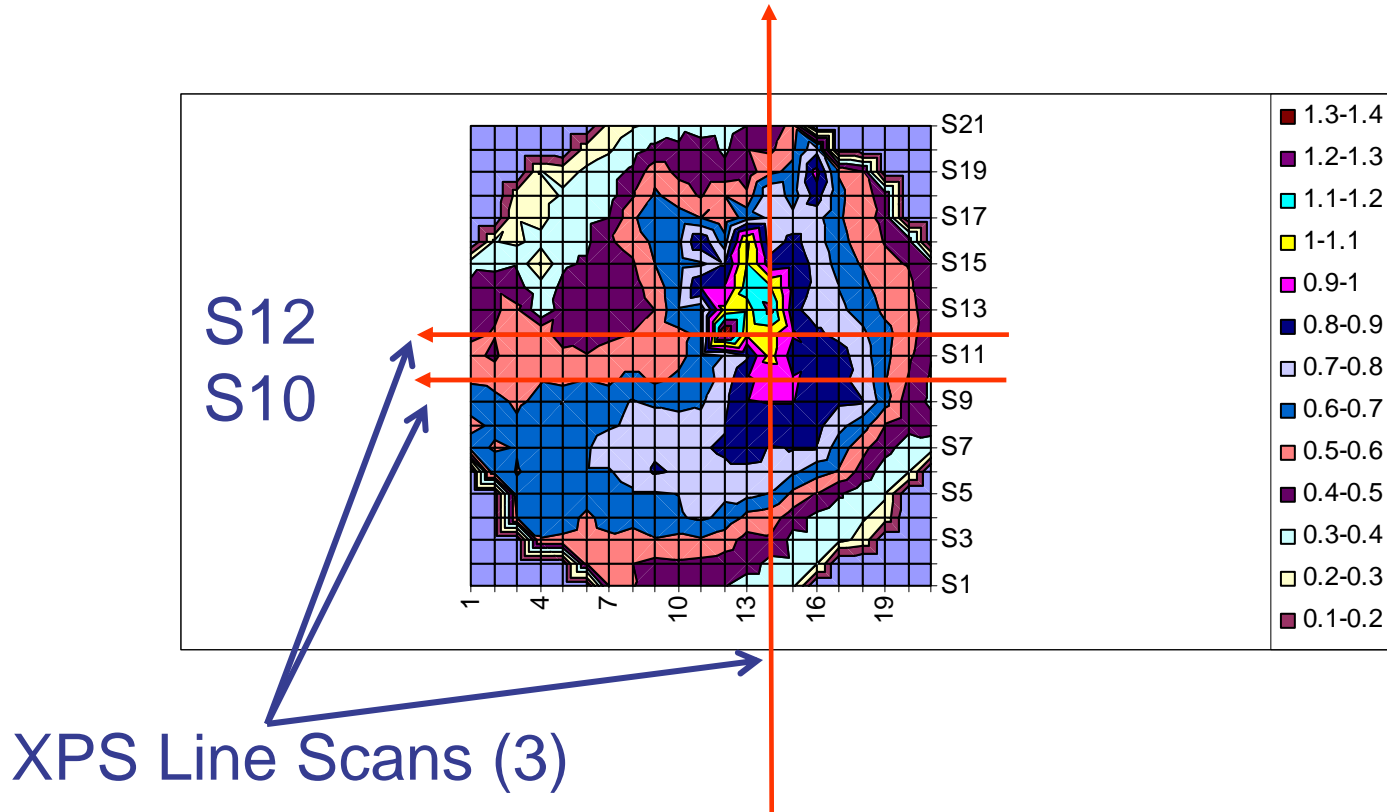


Ellipsometry map

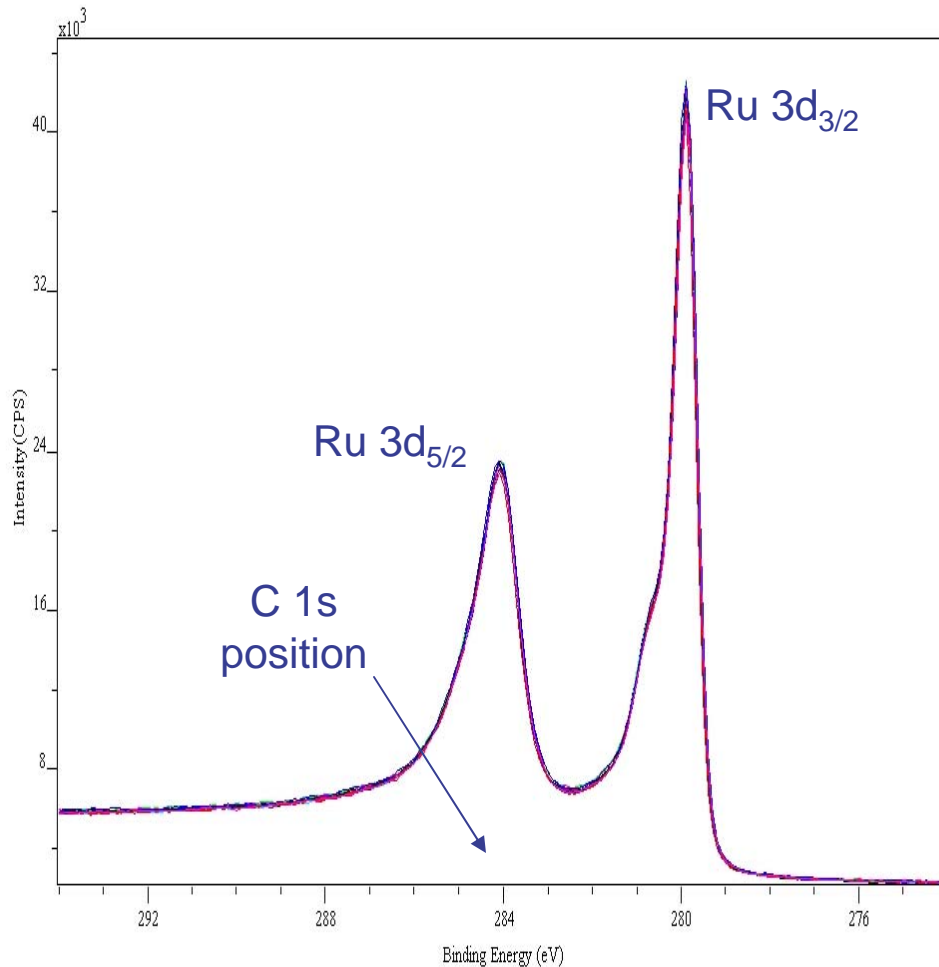
Stage tilt correction has been applied to the ellipsometry map

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

Ellipsometry results of witness sample

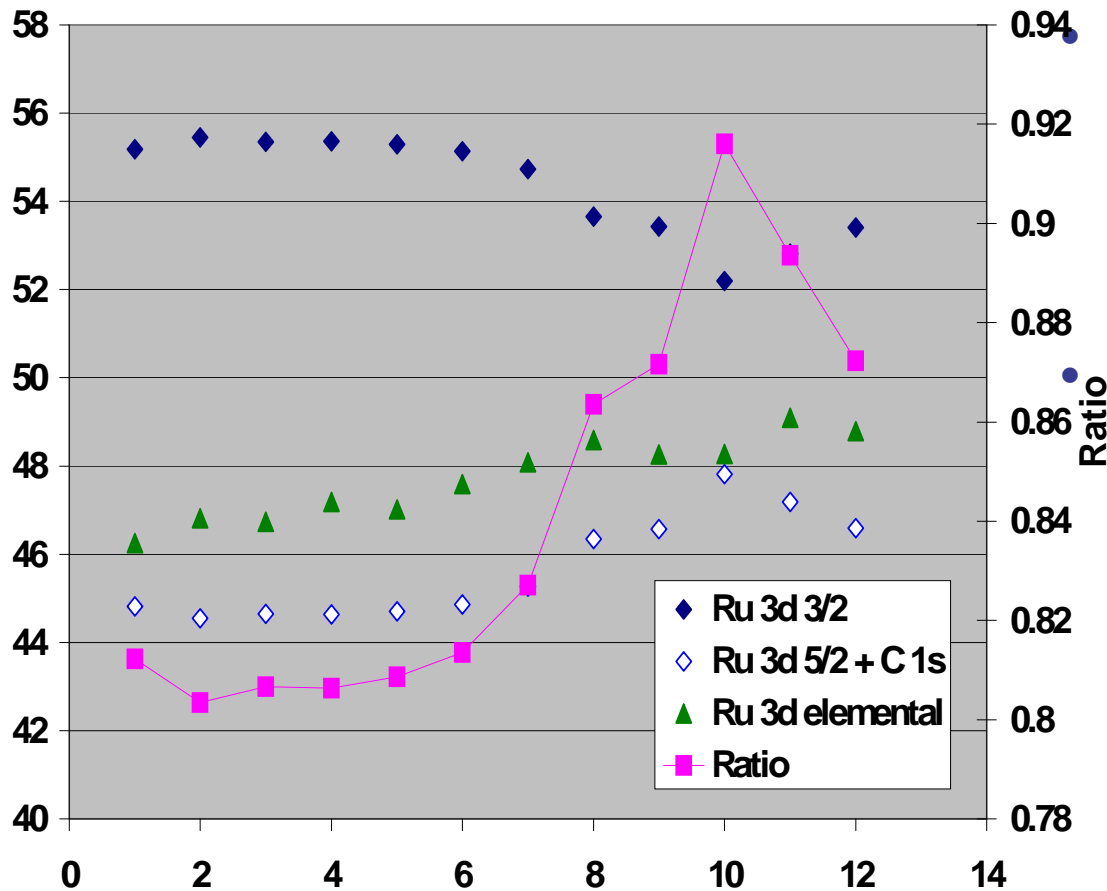


XPS Measurements



- 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

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



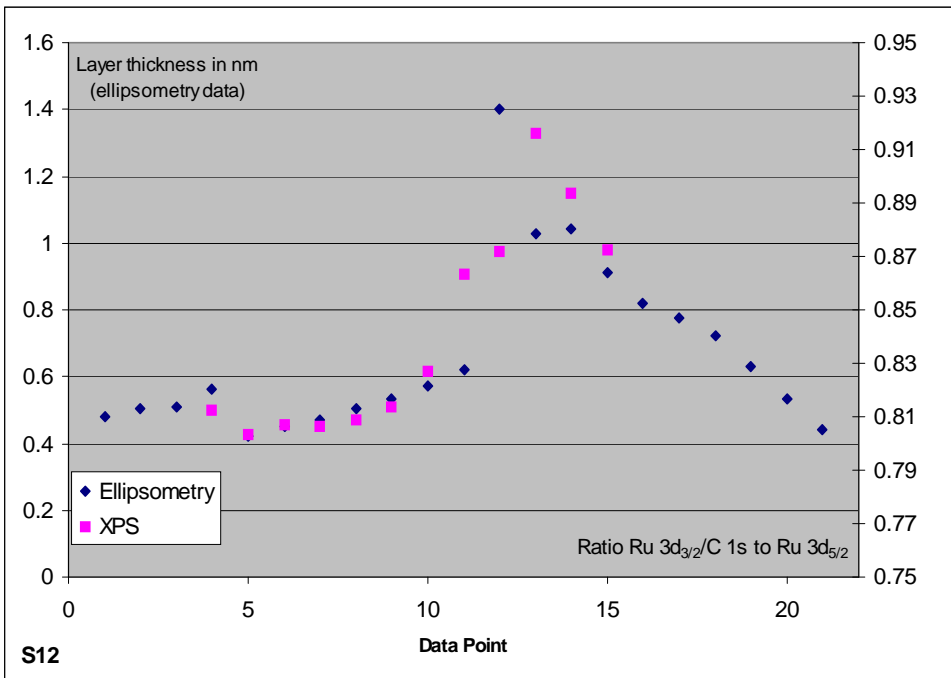
Total Ru signal decreases with increasing C film thickness due to lower sensitivity of C compared to Ru

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

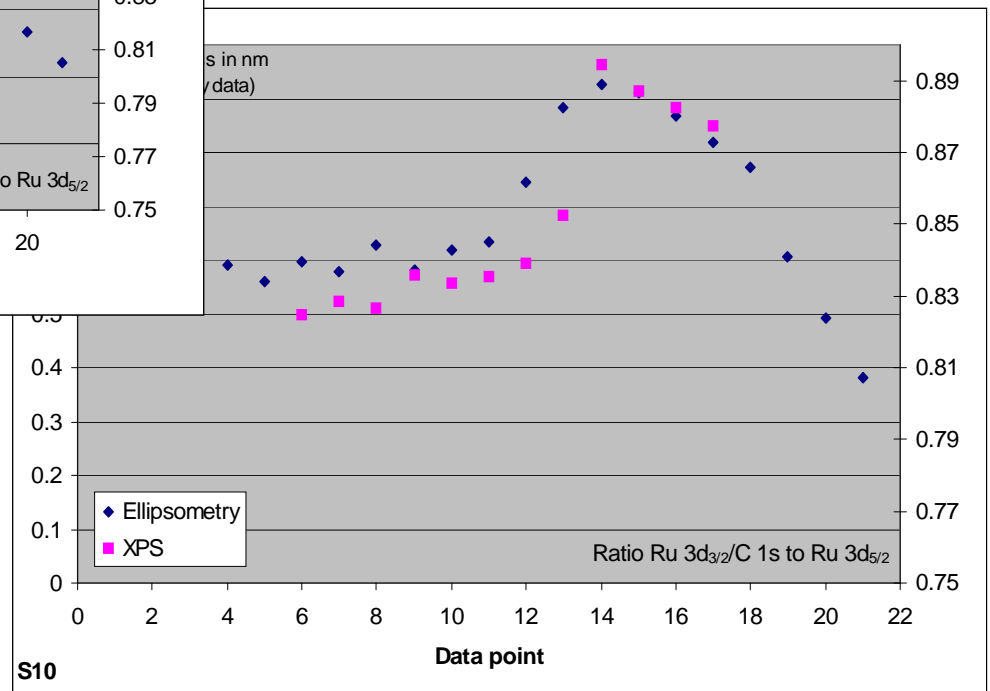
S12 scan

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))

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)

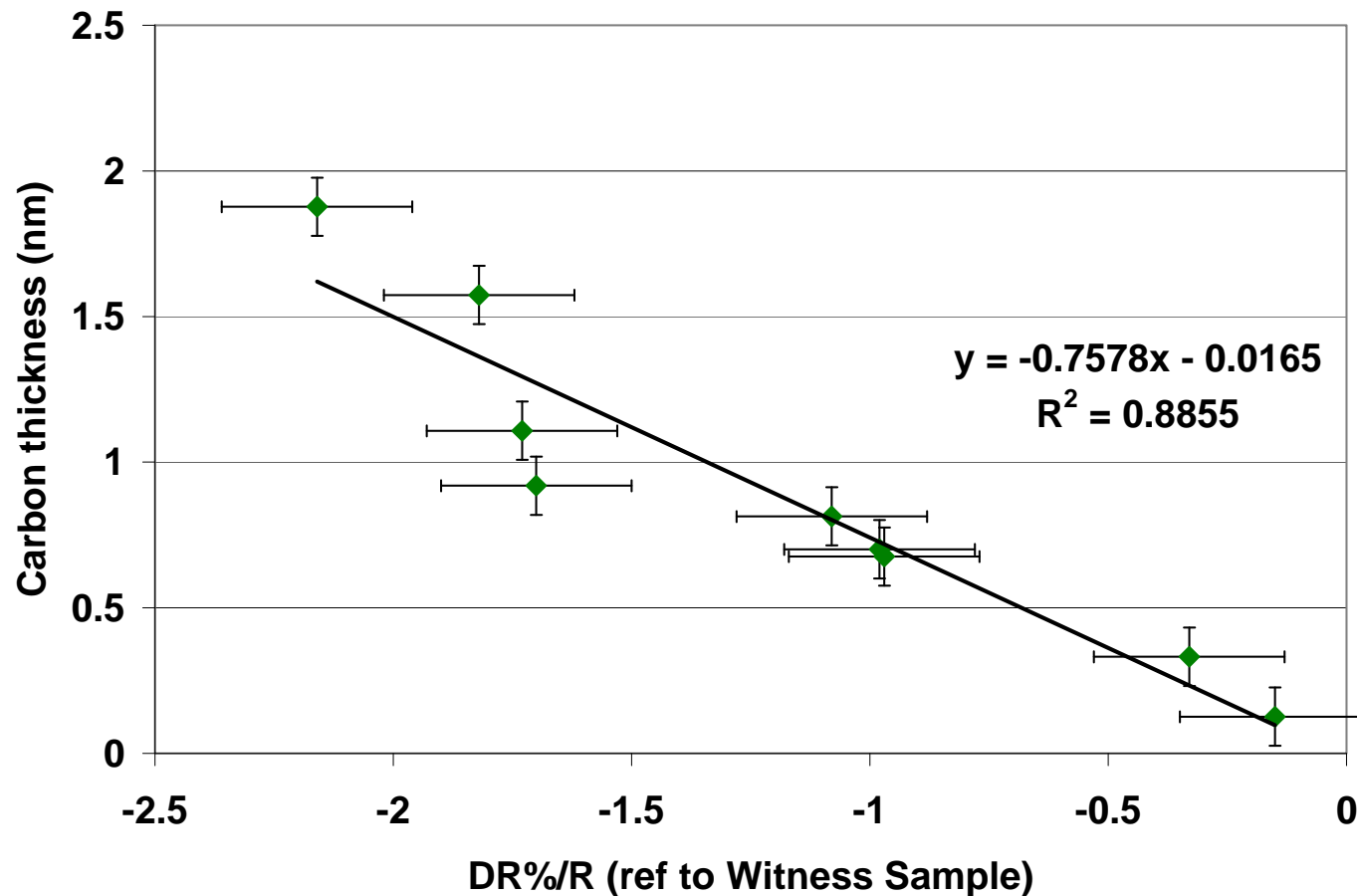
C 1s

	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

Good correlation between reflectivity loss and carbon thickness



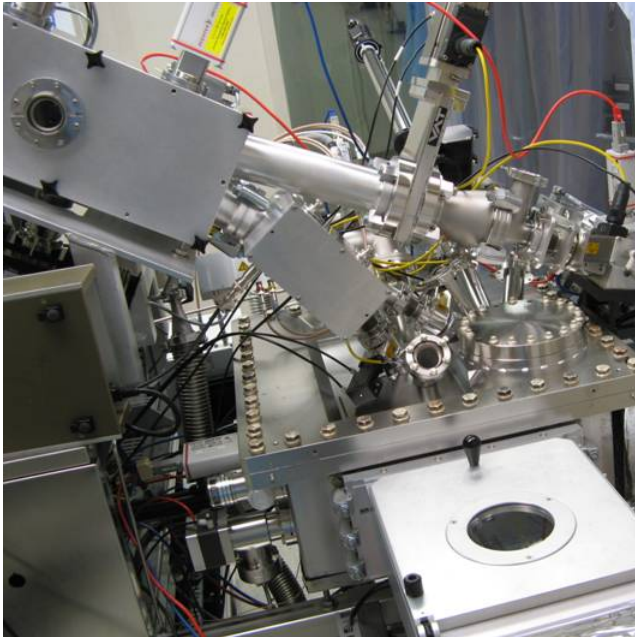
- Sensitivity is ~1.3% reflectivity loss/nm carbon growth
- Each point is a separate sample

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”



IMEC collaboration on outgassing



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

- Hardware characteristics
 - EUV exposure using Energetiq EQ-10R source ($10W/2\pi sr$)
 - Vacuum $\sim 1e-8$ mbar, 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