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# EUV Pellicle Reflection & Transmission Tool EUV-PRTT

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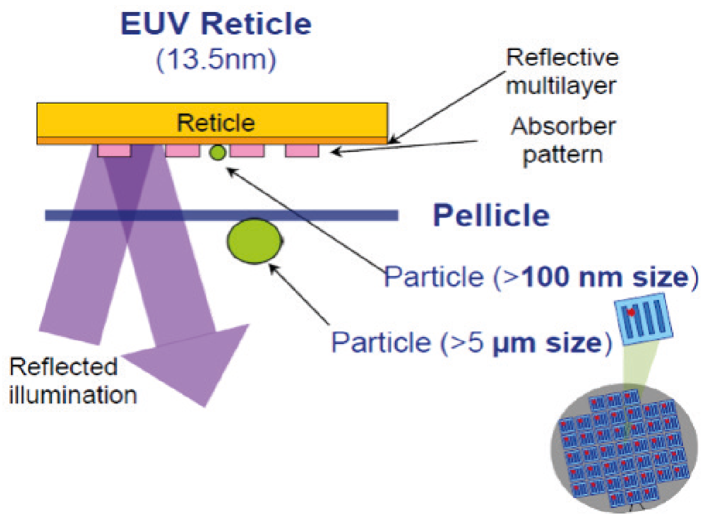



Schematic of pellicle function (R. Peeters, ASML, SPIE 2014, San Jose)

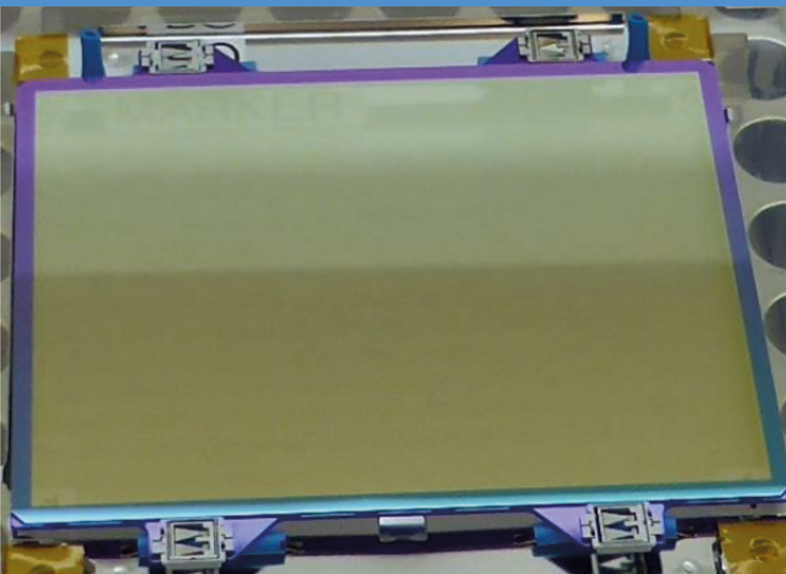


Image of a full size pellicle (ASML)

## Metrology for EUV Pellicles

### Introduction / Motivation

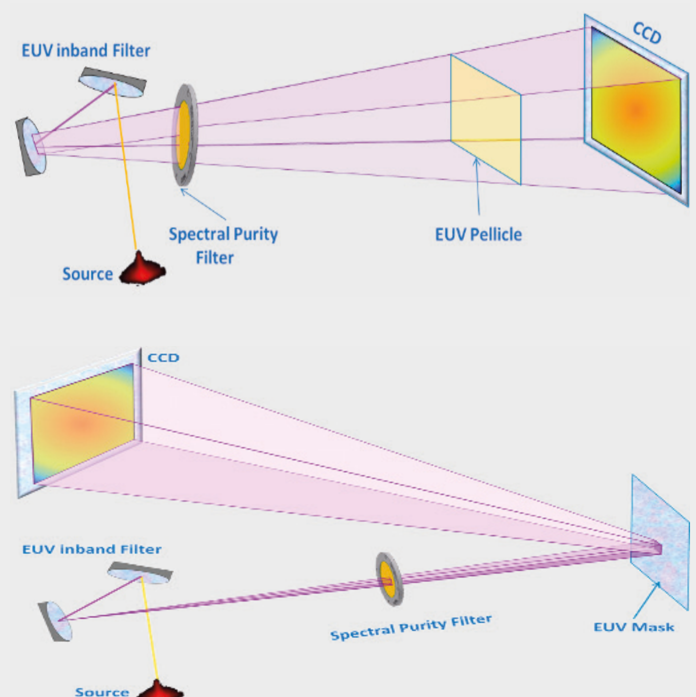
EUV lithography is used for chip volume production. EUV pellicles and dynamic gas lock windows in the scanner are corner stones for the technology. EUV pellicles reduce the impact of particles onto the reticles.

The pellicle is a thin film (≈ 50nm thick) placed above the patterned surface of the EUV reticle and retains particles that would have otherwise landed on the patterned side of a reticle. As these particles are then out of focus, their impact on the imaged pattern is strongly reduced from the nanometer range to the micron range. Dynamic gas lock windows (DGLs) are used in the EUV scanner between projection optics and wafer in order to prevent any contaminants generated during the resist exposure reaching the optics.

Those thin film components have to be qualified in various aspects for reproducible quality for being used in production. In particular, the EUV transmission and reflectance at 13.5nm in the bandwidth used in the scanner have to be quantified over the entire pellicle area such that best quality/ homogeneity for achieving desired CD is verified.

The EUV-PRTT has been designed to qualify pellicles for EUV transmission of around 90% with a precision of better than 0.1% and with reflectivities of < 0.01%.

With reproducibilities and sensitives well below 0.001%. As used in the industrial process for production or in fab use, the EUV-PRT should not add any particles to the sample.




Schematics of the actinic inband EUV (AIMER™) concept used in the PRTT

## EUV-PRTT Concept

### AIMER™ like inband filtering

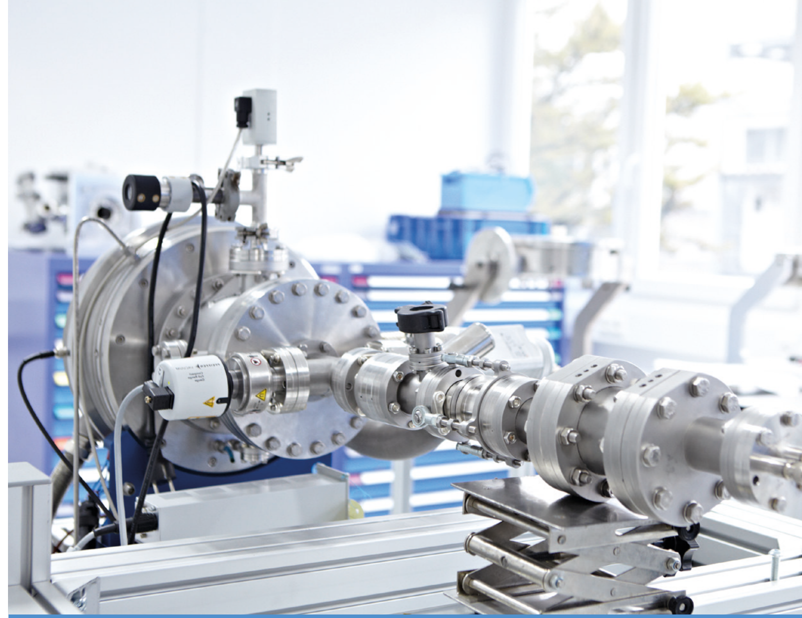
The EUV-PRTT applies RIs actinic inband EUV metrology concept (AIMER™).
The basic concept is to measure the sample "as seen by the scanner", which is that the property of a sample is measured as weighted integral over the spectral bandwidth of the scanner.
In the EUV scanner, the spectral distribution of the wafer exposure is of about 2% bandwidth centered at the central wavelength of 13.52nm due to spectral filtering by the elements between source and wafer. Hence, all radiation incident on the mask is contributing to the total wafer exposures as weighted with the effective spectral transfer efficiency. This situation is resembled in the EUV-PRTT by filtering the EUV-Lamp's broadband emission spectrum to the same spectral bandwidth using two tailored multilayer reflections and spectral purity filtering.
Measuring transmission and reflection properties in this configuration provides the correct figure of merit for scanner use.

## Core quality and design features

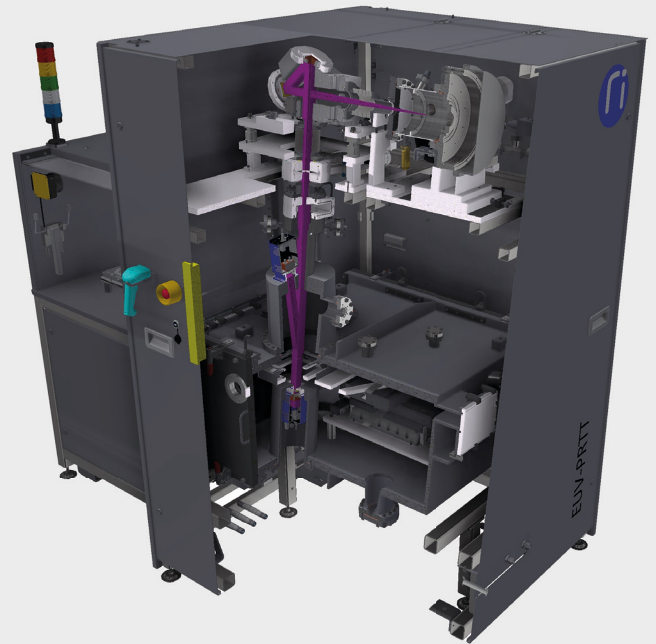
### The core features used in PRTT production tools are:

- Reliable, clean stand-alone EUV-Lamp produces sufficient EUV flux for metrology with high availability
- Effective EUV inband filtering
- Precise dose monitoring
- Cooled Back-illuminated CCD cameras for reflection and transmission measurements
- Clean process environment
- Ultra clean sample stage and transfer design for lowest defectivity

Load port for supply chain version manual loading



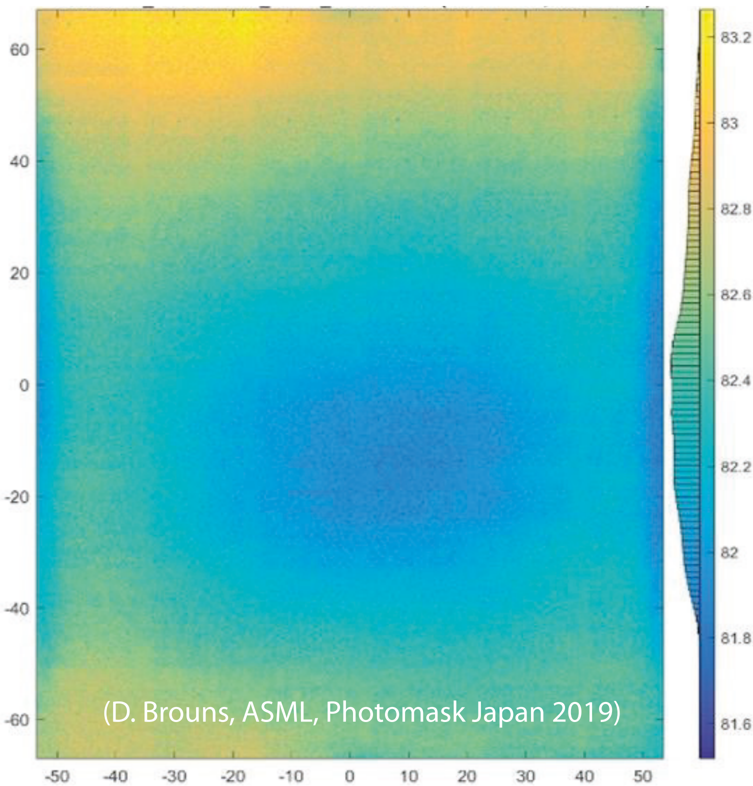
RI EUV-Lamp during testing with E-MON source monitor




Schematics of EUV-PRTT functional elements and beam path

## Tool internal calibration

The transmission channel of the EUV-PRTT is self-calibrating with each measurement, providing stable long-term performance. The reflectance channel can be recalibrated using calibrated reference samples supplied with the tool.
With respect to the spectral range which is measured, the inband filter is accurately designed to CWL50 = 13.52nm as used in the EUVL scanner.




Typical final result of full frame pellicle qualification on T

## Measuring with the EUV-PRTT

### Measuring Process of the EUV-PRTT

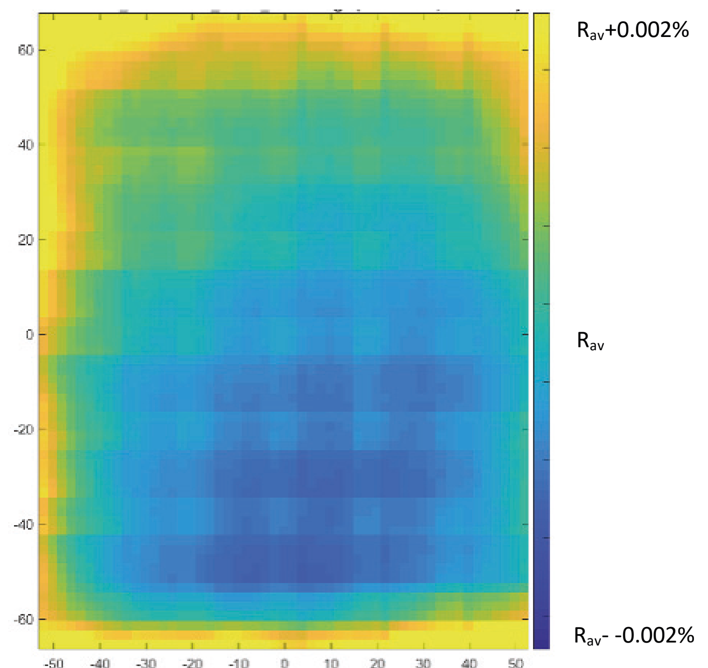
In the standard configuration, the EUV-PRTT provides a Class 1 mini-environment for manual loading and unloading of the pellicle from the transport assembly to the load lock of the system. Transfer of the pellicle to the vacuum system is fully automated.
The Graphical User Interface guides the operator through all necessary steps for measurement execution.

The transmission and reflection measurements are performed simultaneously, the inbuild data evaluation and reporting system provides the user with a measurement report and possibility to automatically compare the pellicle against a set of adjustable acceptance criteria.
Remote control of the system is possible and interfaces to FAB automation systems can be provided.

## Throughput and availability

In the standard configuration, the EUV-PRTT achieves a throughput of 2hrs/pellicle for a complete reflection and transmission map.
Upgrade options are available to achieve cycle times below 90 minutes.

The EUV-PRTT is suited for 24/7 operation and has achieved availabilities of >95% uptime.




Pellicle reflectance of < 0.1% measured in less than 1 hour with 13µm intrinsic resolution

## System specifications

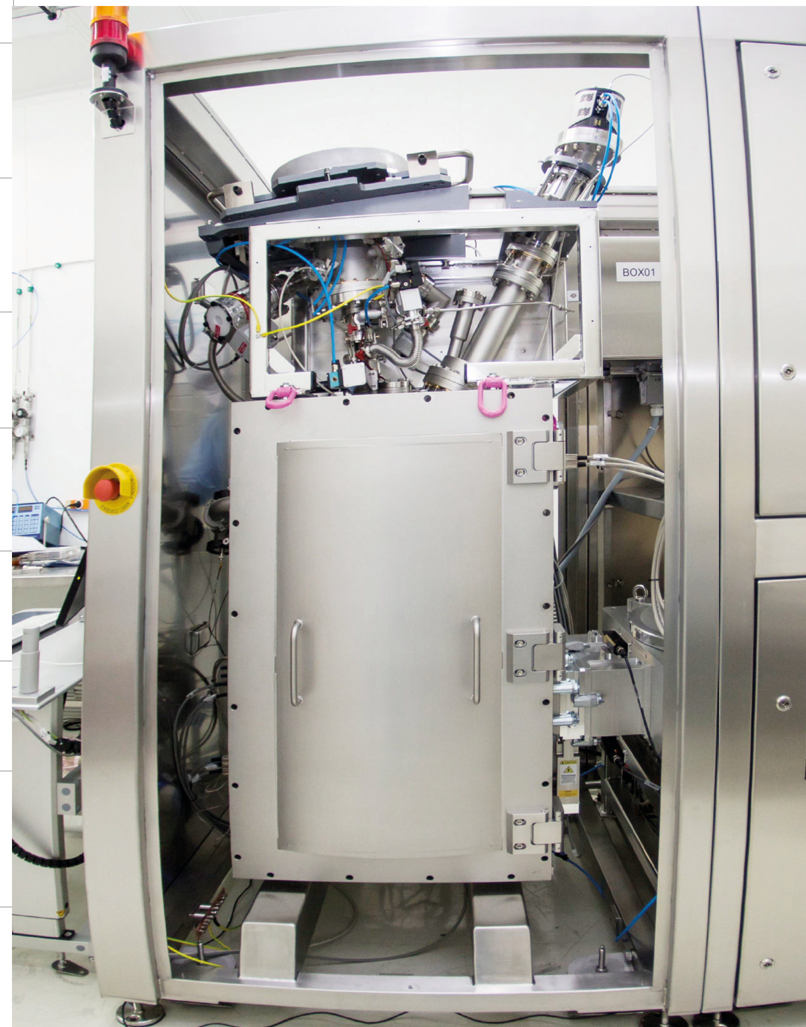
| Channels | EUV reflectivity (R) and transmission (T) |
|---|---|
| Wavelength | 13.52nm ± 0.05nm, 2% Bandwidth |
| AOI | 6deg ± 0.2deg |
| T&R CCD resolution | 13.5x13.5µm$^2$ |
| R – Accuracy | 0.01% abs. at 2x2mm$^2$ Quality Bin Size (QBS) |
| R – Reproducibility | 0.005% abs. at 2x2mm$^2$ QBS |
| R – Sensitivity | 0.002% abs. at 2x2mm$^2$ QBS |
| R – QPx Resolution | 2x2mm$^2$ |
| T – Accuracy | 0.1% abs. at 0.8x0.8mm$^2$ QBS |
| T – Reproducibility | 0.1% abs. at 0.8x0.8mm$^2$ QBS |
| T – QPx Resolution | 800 x 800µm$^2$ |
| Defectivity, # | <1/100 particles > 10µm added per cycle |
| Cycle time | 2 hr for full size R & T maps, load, unload |

## Distinctive EUV-PRTT features are:

- Full area transmission and reflection quality map
- Simultaneous measurements of T and R
- Designed for lowest defectivity level
- Position self referencing to pellicle borders
- Overall wavelength accuracy better than 20pm.
- Photon Shot Noise limited reproducibility
- Reliable source with typically 400 million pulses service interval and MTBF
- Class 1 cleanroom local environment for loading / unloading.

## We customize to your needs

The EUV-PRTT meets the extreme demands from the semiconductor industry on EUV-metrology. Our EUV tools are kept compliant with the relevant Standards (SEMI) and are only examples of our customer tailored solutions.
We encourage you to contact the RI team for discussing your needs and applications.



RI Research Instruments GmbH (RI) supports the EUVL infrastructure with actinic metrology and test solutions and components. Special focus is on meeting industrial expectations like cutting edge resolution and precision, ultra cleanliness, high uptime and cost effectiveness.

## Teamwork makes the dream work.

Let's team up and see how our experts can support your cause.

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