Bruker ASC

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Contributions to EUV mask metrology infrastructure: Reflectometer, Blank Inspection and DPP+LPP EUV Sources

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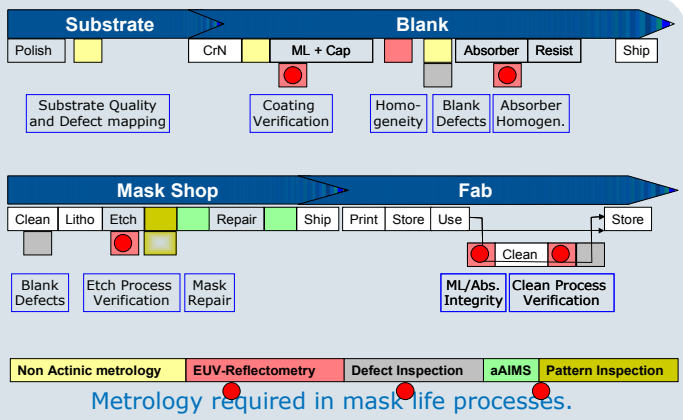
Abstract

BASC and our partner can offer to deliver key issues and tools for stand alone actinic mask metrology infrastructure.

With our EUV-reflectometer we are ready to fulfill HVM requirements in accurate and sensitive spectral metrology. Transfer from mask blanks to masks is supported with integrated fiducial mark detection, small spot metrology and clean design solution. For actinic blank inspection a proof of concept experiment based on an EUV microscope at BASC's EUV-Lamp allows for comparing actinic signatures with AFM scans. Results allow for extrapolation to sub 30 nm sensitivity and fast full blank scan. Based on LPP high-brightness sources of > 100 W/mm²/sr in single emission line as realized for x-ray microscopy, we demonstrated a new concept with new laser and target concepts for high position stability, gain, power and efficiency in a proof of concept.

Contributions to Metrology

BASC and it's partners may contribute keystones to actinic EUV mask actinic metrology infra-structure. On our scope are EUV-Reflectometer, Actinic Blank Inspection Tool, high brightness sources for nanoimaging and average power EUV-sources for accelerated lifetime testing.

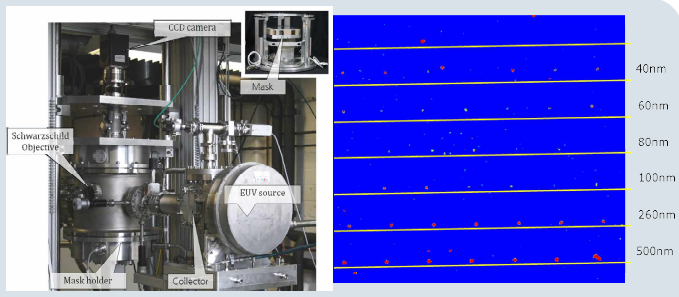


Metrology required in mask life processes.
BASC can contribute tools and components for actinic.

Actinic Blank Inspection

Based on an EUV-Microscope, we investigate the realization of an effective actinic concept for defect detection on multilayer mirrors such as mask blanks.

For the time being, the detection of defects has been verified and proven based on surface defects generated on multilayers. Studies on natural defects are underway.



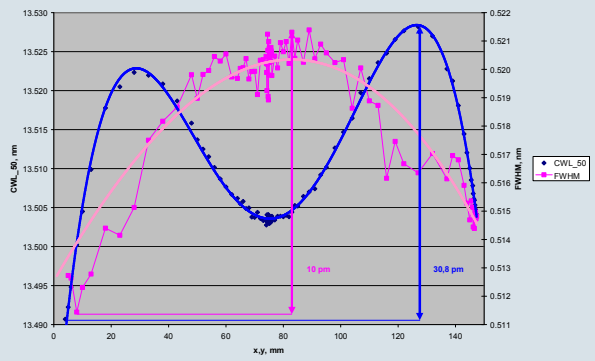
Set-Up of dark field actinic defect detection experiment and results from programmed defects detected on multilayer mirror down to 40 nm design size.

EUV-Mask Reflectometer

The EUV-reflectometer developed and used for mask blanks is permanently under improvement to stay in line with the demands of the ITRS roadmap and meet the expectations for EUVL ramp-up and allow for measuring on structured masks. For this purpose we have one tool is in operation at our lab to be used in European project EXEPT with our partners and to be available for third party's investigations.

EUV-MBR test tool as operated at BASC

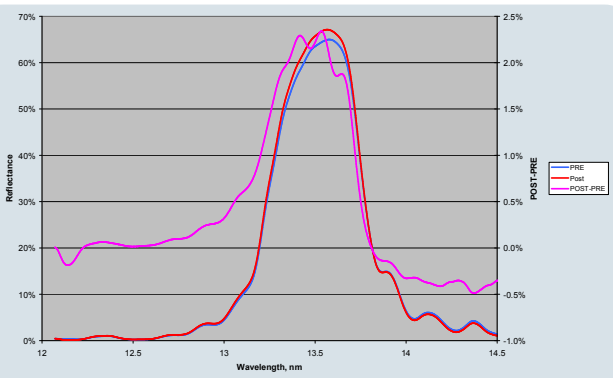
Demonstrated high throughput of better than spot measured per minute, high immanent spectral resolution of 1.6 pm, immanent wavelength calibration of each measurement and parallel measurement of tool stationary reference samples allows for unsurpassed quality and the option to perform measurements with high demands on data densities and reproducibility.



Diagonal scan over mask blank at 90 spots taken in 1 hour automatic mode demonstrates potential of MBR

Process Control with MBR

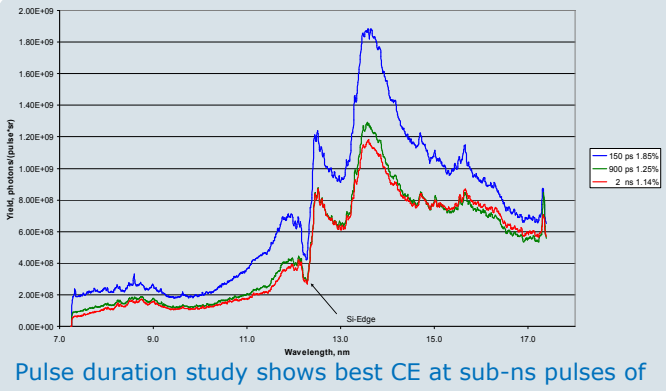
Together with partners from EXEPT, we investigated the influence of a process on EUV-mask blanks. We compared spectral reflectance before (Pre) and after (Post) applying the process



Comparison of spectral reflectance Pre and Post. Improvement of peak reflectance by 2%, shift of CWL_50 by – 2 pm and reduction of FWHM of 0.8 pm were found.

High Brightness EUV-LPP

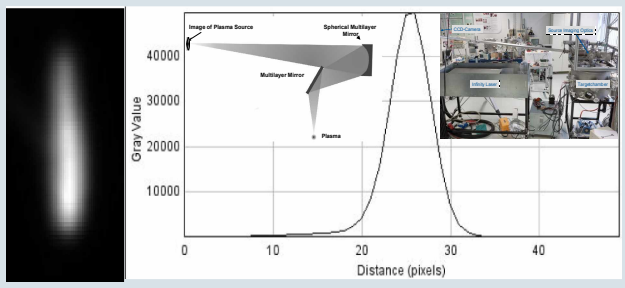
As the most effective source for nano-imaging tasks as AIMS or actinic blank and mask inspection, we are suggesting tailoring the EUV-source to small source size. Assuming only 1.5% CE, a 100 W/mm²/sr would require only a regenerative target of liquid tin with integrated means of permanent material exchange, surface stabilization against waves and with close loop height control to better 5 µm, debris mitigation. A first proof of principle set up has been realized tested and used for the experiments described.



Pulse duration study shows best CE at sub-ns pulses of 1.85 % on liquid bath target.

Results

With experimental all solid-state laser from ILT with pulse energies of 2-3 mJ per pulse and variable pulse duration of 0.15 – 2 ns, we demonstrated 1.85 % CE, > 45 mW/ (2πsr) LPP inband EUV source with diameter of <20 µm, which is > 25 W/mm²/sr in permanent operation @ 1 kHz and > 250 W(mm²sr) for minutes at 10 kHz (25 W) operation.



9 times magnified inband EUV-Image of source and horizontal profile on CCD with 20 µm pixel. Schema of set-up and in RAC-Lab as insert.

Conclusions & Outlook

We have demonstrated key components for actinic mask metrology:

- The EUV-Reflectometer for masks and blanks reaches HVM throughput and quality (spot reproducibility: R_90 < 0.1 % and < 1 pm in CWL_50) with 50*250 µm² spot and < 1 minute total per spot.
- We demonstrated concept of actinic defect inspection.
- We have demonstrated new source concept with > 250 W/mm²/sr scalable to > 2000 W/mm²/sr

EUV-Sources and Solutions