Reflectometry for full-size EUV collector mirrors for high power LPP sources

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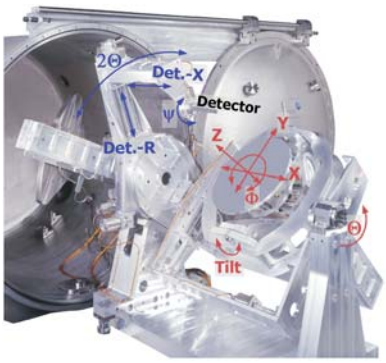
Introduction

Source power is still an issue for the commercialization of EUV lithography. LPP sources with large solid angle, normal incidence collector mirrors are an option for the realization of high-power HVM sources presently developed by Cymer Inc. The mirror which must provide high EUV reflectance in the rough environment close to the hot source plasma is one of the key components. PTB with its EUV reflectometry facility at BESSY II supports the development of high-reflectance thermally stable coatings by the Fraunhofer IOF. We present the methods and results for the characterization of collector mirrors with an outer diameter of 670 mm; the largest EUV optical components presently available. Special attention is given to the aspect of polarization which is important for the oblique angles of incidence needed to cover 5 srad collection angle. We discuss how the low uncertainties of PTB's reflectometry were maintained under the special operation conditions required for the collector mirrors.

Conclusion

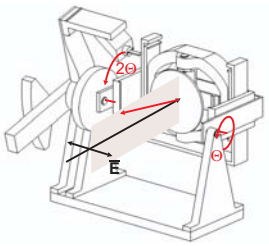
Methods and results are presented for the characterization of large collection angle EUV collector mirrors with an outer diameter of 670 mm. Special routines were developed to measure at oblique angles of incidence with varying polarization using the versatile mechanics of the EUV reflectometer. A detailed analysis of the polarization properties of the beamline yielded an improved degree of polarization for the monochromatized radiation. A careful characterization of the alignment of the reflectometer mechanics maintained the low uncertainties of PTB's reflectometry under the special operation conditions required for the collector mirrors. Presently, about 65% reflectance for S-polarized light and wavelength homogeneity within a band of only 0.03 nm are achieved up to a radius of 300 mm on the mirror optical surface. Area-averaged mirror reflectance values for unpolarized incident light exceed 50%.

Instrumentation

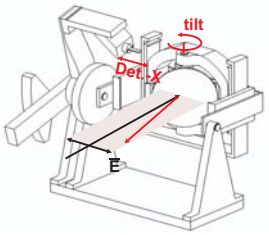


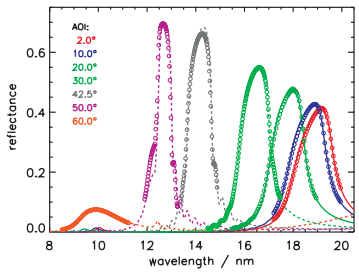
The reflectometry samples (i.e. small test coatings or EUV mask blanks) are mounted on a plate in local clean room environment and loaded into the reflectometer chamber by a robot.

Measurement scheme

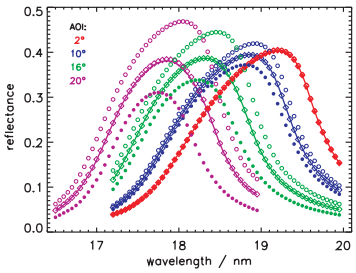


Realization of arbitrary polarization geometry with the EUV reflectometer: The instrument is designed for S-polarization with the axis of rotation parallel to the electrical field (left). Using the tilt-axis and the off-plane detector movement, Det-X, also P-polarization is assessable up to 20° angle of incidence (right).





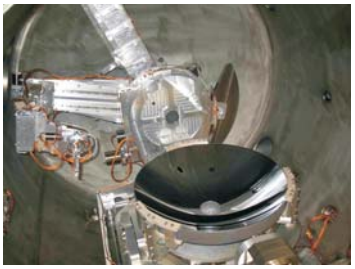
Reflectance of a Mo/Si multilayer mirror with 10.1 nm period measured for different angles of incidence in S-pol., open circles. The dashed lines represent a best-fit model of a periodic layer structure including interface roughness and diffusion layers.

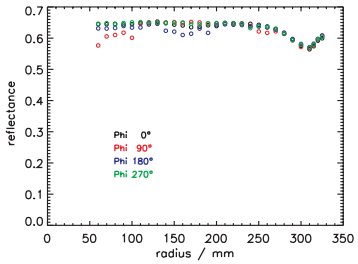


Reflectance of a Mo/Si multilayer mirror measured for different polarization orientation, open circles: S- and closed circles P-pol. The solid lines are the average values of S- and P-pol. and the diamonds are measured at 45° orientation of the linear polarization.

References F. Scholze, J. Tümmler, G. Ulm, Metrologia **40**, S224-S228 (2003), J. Tümmler et al., Proc. SPIE **5037**, 265-273 (2003)

Results

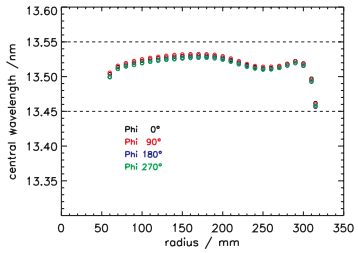




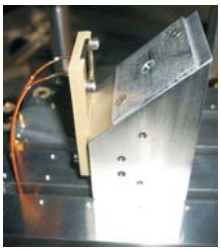
5-srad EUV collector in PTB reflectometer

LPP EUV collectors are at present the largest EUV optical components, having an outer diameter of 670 mm. The coating must combine high environmental stability and high and homogeneous EUV reflectance

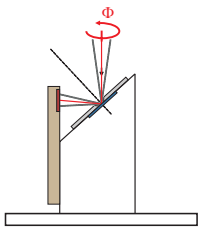
Upper right: measured reflectance
Lower right: measured center wavelength

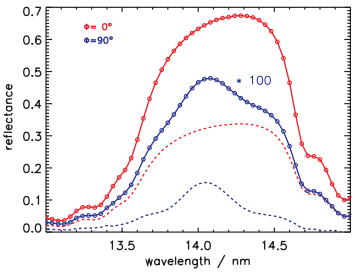


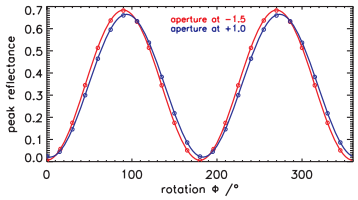
Characterization of the linear polarization at the radiometry beamline



Scheme of the polarimeter: A Mo/Si multilayer mirror is mounted at the Brewster angle of 42.5° with a photodiode for detection of the reflected light. The whole mount is rotated around the incident beam direction using the Φ axis of the reflectometer.

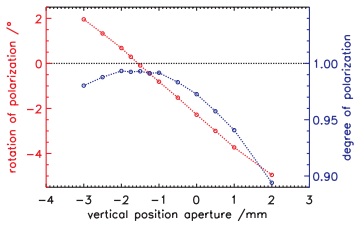






Above: Reflectance at the Brewster angle (red S- , blue P-pol). Note the different shape of the reflectance of the S-polarized component in this orientation and the small but finite reflectance for P-pol. light.

Upper right: measured reflectance as function of polarization orientation, lower right: degree of polarization and main axis orientation as function of entrance aperture position. Synchrotron radiation from bending magnets is linearly polarized in the orbital plane and right, respectively left-handed elliptical above and below. For a finite vertical aperture size, the resulting linear polarization thus is always below 1 and the main axis of the resulting polarization ellipse rotates if the aperture is placed asymmetrical to the orbital plane.



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