Solutions with light – meet challenges and offer opportunities
Multilayer coating for EUV collector mirrors

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Multilayer coating for EUV collector mirrors

Contents

- Introduction
- Characterization of LPP collector substrates
- Multilayer coating of LPP collectors
- Summary and acknowledgement
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Coating and characterization of LPP collector optics

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LPP collector coating challenges

\[ R > 65 \% \]
\[ \lambda = (13.5 \pm 0.03) \text{ nm} \]
\[ \Rightarrow \Delta d = 0.015 \text{ nm} = 15 \text{ pm} \]

- Diameter: > 660 mm
- Lens sag: > 150 mm
- Tilt: > 45 deg
- Weight: > 40 kg

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Surface characterization of EUV collector substrates

- No robust roughness data available
  - Complex geometry
  - Required roughness sensitivity

- New approach: Roughness characterization through light scattering measurements at $\lambda = 405$ nm
  - Non-contact
  - Fast, robust
  - High sensitivity
  - Information about roughness, defects, homogeneity, …

→ Superior characterization method for EUV collector mirrors before coating
The basics: Scatter modeling of EUV multilayer coatings

- Separate effects of substrate and thin film ML
- Roughness enhancement of ML = f(substrate roughness)
- Influence of substrate roughness becomes dominant if HSFR > 0.1 nm

→ Important basis for prediction of EUV performance of given substrate before coating

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→ Perfect fractal behavior at smooth and rough areas
→ Prediction of performance at 13.5 nm based on detailed roughness information (PSD, HSFR)
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Prediction based on roughness data obtained from scattering (before coating)

Reflectance measurements at PTB, Berlin (after coating)

→ Good correlation between predicted and experimental data
→ Accuracy of average predicted reflectance < 1%

Reflectance drops to 35 %
Multilayer coating for EUV collector mirrors

- Fast data acquisition: mapping of entire sample surface (100% characterization)
- High sensitivity to roughness (average HSFR = 0.1 nm)

Thorough characterization of collector substrate before coating

Check for homogeneity and defects
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NESSY – ‘New‘ EUV Sputtering System

Design and realization of an EUV sputtering system

Conception:

- magnetron sputtering of rotating and fast spinning substrates up to Ø 665 mm
- four deposition targets
- deposition of graded multilayers on curved substrates
Multilayer coating for EUV collector mirrors

Reflectivity of LPP collector mirror

Maximum reflectance along four lines within clear aperture of collector mirror:

\[ R \approx 65\% \ @ \ r < 240 \ mm \]
\[ R \approx 62\% \ @ \ r = 250 \ldots 320 \ mm \]

Measurements: PTB Berlin
Multilayer coating for EUV collector mirrors

Reflectivity of LPP collector mirror

Center wavelength along four lines within clear aperture of collector mirror:

\[ \lambda = (13.50 \pm 0.03) \text{ nm} \]

Measurements: PTB Berlin
Multilayer coating for EUV collector mirrors

Reflectivity of LPP collector mirror

Measurement of reflectance along four lines within clear aperture of collector mirror:

108 measurement curves

Measurements: PTB Berlin
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Summary

Characterization of EUV collector optics:
- development of light scattering techniques for HSFR substrate characterization
- predict EUV reflectance before coating

Multilayer coating of EUV collector optics:
- R > 65 % and d-spacing accuracy of \( \Delta d < 15 \text{ pm} \)
  on world’s largest EUV multilayer mirror (\( \varnothing > 660 \text{ mm} \))
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