Wir schaffen Wissen – heute für morgen

Paul Scherrer Institut
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Wavefront metrology measurements at SACLA by means of X-ray grating interferometry
Grating based interferometry
- Application domains
- Working principle

Single-shot metrology measurements at the SACLA hard X-FEL
- Radius of curvature
- Mirror and monochromator surface
Applications of grating interferometry

Grating interferometry at the PSI

Phase contrast imaging
(synchrotron sources, x-ray tubes, neutron sources)

X-ray metrology
Metrology of X-ray optics

T. Weitkamp, B. Nöhammer, A. Diaz, C. David, and E. Ziegler,
X-ray wavefront analysis and optics characterization with a grating interferometer,
S. Rutishauser, A. Rack, T. Weitkamp, Y. Kayser, C. David and A. T. Macrander, 
*Heat bump on a monochromator crystal measured with X-ray grating interferometry*, 
Metrology of X-ray optics

S. Rutishauser, L. Samoylova, J. Krzywinski, O. Bunk, J. Grünert, H. Sinn, M. Cammarata, D. M. Fritz, and C. David,
Exploring the wavefront of hard X-ray free electron laser radiation,
Hard X-ray grating interferometry

Sensitivity: \[ S \propto \frac{p_2}{d} = \frac{[\mu m]}{[m]} = [\mu rad] \]

Detect 1 fringe \[ \frac{1}{100} \rightarrow 10 nrad \]
Gratings

Beam splitter grating (G1)

Analyzer grating (G2)

$h_1 = 4 \, \mu m$

$p_1 = 4 \, \mu m$

$h_2 = 2 \, \mu m$

$p_2 = 2 \, \mu m$
Measurements at the SACLA XFEL

 XFEL beam

 Beam splitter grating (G1)

 Analyzer grating (G2)

 Detector

 $d$
Grating rotation scan

H. Wang, K. Sawhney, S. Berujon, E. Ziegler, S. Rutishauser, and C. David,
*X-ray wavefront characterization using a rotating shearing interferometer*,
Results: Mirrors (M1 & M2A, $E_B = 7$ keV)

Vertical Grating Lines ($ROC_H = 153$ m)

Wavefront slope error $[\text{mrad}]$
Results: Mirrors (M1 & M2A, $E_B = 7$ keV)

Horizontal Grating Lines ($\text{ROC}_V = 108$ m)

Wavefront slope error $[\text{m rad}]$

Profile $[\text{nm}]$ x $[\text{mm}]$

Wavefront slope $[\text{m rad}]$

Aspherical soft x-ray mirrors profile

Soft x-ray mirrors profile
Results: Mirrors (M1 & M2B, $E_B = 12.4$ keV)

- Vertical Grating Lines (ROC$_V = 153$ m)
- Horizontal Grating Lines (ROC$_V = 74$ m)

20 mm

2 mrad
Results: Mirrors (M1 & M2B, $E_B = 12.4$ keV)

Horizontal Grating Lines ($\text{ROC}_V = 74$ m)

Profile

- Aspherical hard x-ray mirrors profile
- Hard x-ray mirrors profile
Results: Double Crystal Monochromator ($E_B = 12.4$ keV)

Horizontal Grating Lines ($ROCV = 150$ m)

DCM

Profile [nm] x [mm]

Aspherical double crystal monochromator profile

Double crystal monochromator profile

$x$ [mm]
Conclusion

- In-situ at wavelength wavefront observations at the SACLA hard X-FEL source by means of grating interferometry
- Applied to metrology experiment aiming at spatially resolved wavefront measurements for optics testing
- Result: flat wavefront profiles & optical components of excellent quality

Thanks for your attention!