Trends on X-ray optics for synchrotron beamlines:

large, nested, flat, curved, 1 or 2D, monolayer, multilayer or stripe multilayer

F. Hertlein[1], C. Michaelsen[1], U. Heidorn[1], J. Wiesmann[1], M. Störmer[2]

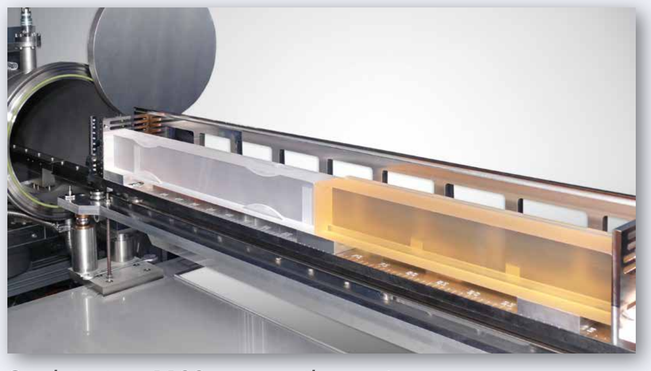
[1] Incoatec GmbH, Max-Planck-Str. 2, 21502 Geesthacht, Germany, [2] Helmholtz-Zentrum Geesthacht, Max-Planck-Str. 1, 21502 Geesthacht, Germany

Introduction

Here, we give an overview on current developments in the coating of large total reflection X-ray optics up to 1500 mm in length, multilayer coatings up to 500 mm, multi-stripe multilayer optics for tomography beamlines and Montel optics (nested KB) for Synchrotron applications.

Total Reflection Optics for Synchrotron Beamlines

Total reflection optics for synchrotron beamlines are needed for beam guidance and beam alignment. This type of X-ray optics is used at grazing incidence angles, therefore more and more optics with lengths of 1000 mm and longer are needed.



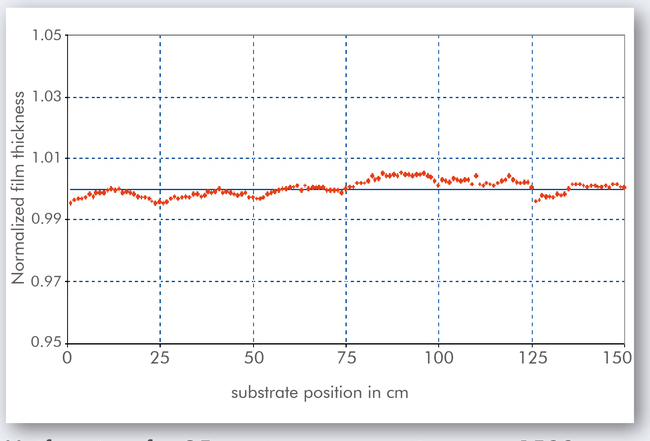
2 substrates -1100 mm- on the carriage.

1000 mm Si mirror with special carbon coating.

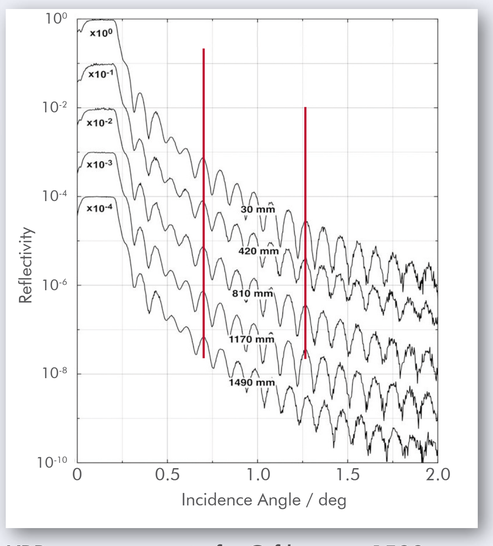
A new sputtering system for the deposition of single- and multilayers has been installed at the Helmholtz-Zentrum Geesthacht. This system enables us to produce coatings up to a length of 150 cm. The variation in film thickness over the whole length of 150 cm has been investigated by X-ray reflectometry. Good uniformity and low roughness (< 0.5nm) were observed.

Tungsten coating	
deposition length	*1500 mm*
Mean film thickness	*35 nm*
Peak-to-Valley	*0.35 nm*
Uniformity	***1.0 %***

Carbon coating	
deposition length	*1500 mm*

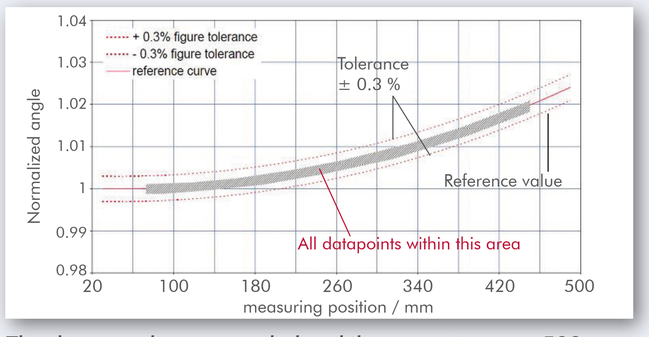


Uniformity of a 35 nm tungsten coating over 1500 mm. Uniformity of thickness is better than 1%.



XRR measurement of a C-film over 1500 mm length (measured by M. Störmer).

500 mm Multilayer Coating with 200 Pairs

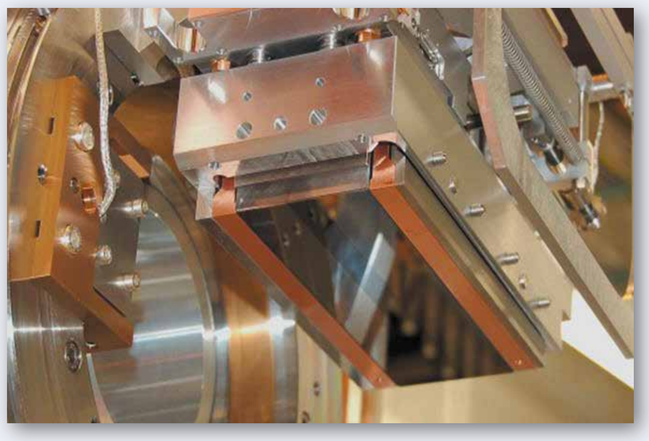


The diagram shows a graded multilayer coating over 500 mm. The deviation of the desired shape in the longitudinal direction is less than ± 0.2 %. First optics were sold to the US.

Bendable 400 mm silicon mirror

Multi-stripe Multilayer Optics

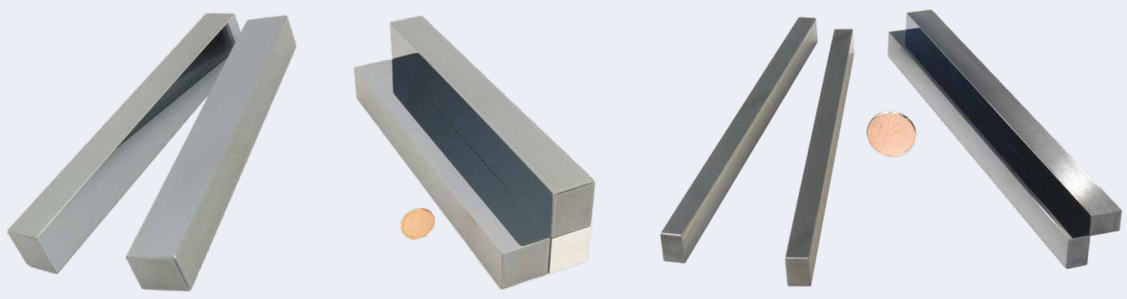
At imaging beamlines multilayer optics are often used as double crystal multilayer monochromators (DCMM). For example, tomography needs a homogeneous and stable beam profile, in order to perform optimal background corrections. Because of the high coherence of radiation, the optical components must be designed with particular care in order to avoid a deterioration of the beam quality. Multilayer coatings with up to 5 stripes were produced with films homogeneities < 0.2% as well as with lateral gradients.



Stripe A: *[Ru/C]100, d=40 Å, y=0.5, R > 80 % for 10<E<22keV*
Midspace: *Si<111>, roughness 0.1 nm, slope error 0.04“*
Stripe B: *[W/Si]100, d=30 Å, y=0.5, R > 80 % for 22<E<45keV*
(Photograph: M. Stampanoni, PSI, Switzerland)

Three-striped multilayer optics for tomographic microscopy and coherent radiology, with an optimized coating for different beam energies (TOMCAT at SLS, Switzerland).

Montel Optics for Synchrotron Applications in Different Sizes



120 mm long Montel Optics with a cross section of 40 x 40 mm

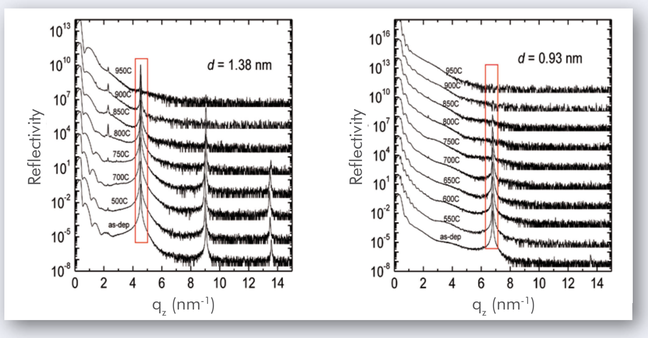
150 mm long Montel Optics with a cross section of 15 x 15 mm

Both optics mounted without apertures.
First optics, with slope errors < 2 arcsec, were sold to NSLS and Diamond for scattering experiments.

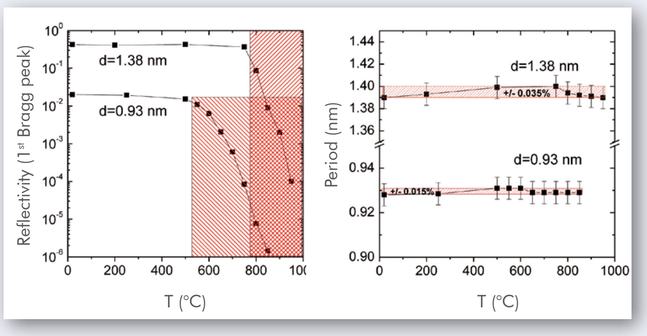
The future: Montel Optics up to 150 mm with even smaller cross section by 10 x 10 mm

Thermal Stability of Ultra-Short Period Mo/ B_4C Multilayer

X-ray reflectivity after rapid thermal annealing



Evolution of Reflectivity



Multilayer Stack Evolution

Cluster Formation in Ultra-Short Period Mo/B_4C Multilayer Studied by GISAXS Technique

GISAXS technique was applied to study interfaces in two ultra-short period Mo/ B_4C Multilayer in terms of the correlation and scaling properties and thermal stability.

Results:

- excellent thermal stability limited by cluster formation and crystallization starting from 750°C was found for the period > 1 nm
- amorphous cluster formation already during deposition and thermal stability up to 500°C were revealed for the period < 1 nm

Matej Jergel, Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia

References

In closed cooperation with HZG, Incoatec has produced total reflection optics consisting of highly-stable carbon, silicon carbide, tungsten or ruthenium and also multilayer coating up to 500 mm as well as multi-stripe optics. First Montel optics with low slope errors are used at beamlines. Many research centers worldwide are using our know-how and our optics, e.g.

Advanced Photon Source · Bessy · Canadian Light Source · Carl Zeiss · Diamond · Elettra · Hasylab at Desy · Horiba Jobin-Yvon · Jenoptik AG · Lyncean Tech. Inc. · NSLS · PAL · Seso · Swiss Light Source

Conclusion

Total reflection and multilayer optics for all kinds of synchrotron applications:

- high precision coatings up to 150 cm in length
- multilayer coatings up to 50 cm
- Montel optics for Synchrotron applications
- multi-stripe multilayer optics as monochromators
- ultra stable carbon coatings for FEL

The high quality and flexibility of the complete production process enable us to offer customized solutions for all kind of thin film synchrotron optics.

Partners

ZEISS

Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

www.incoatec.de

INCOATEC
innovative coating technologies