Trends on Reflective X-ray Optics: large, nested or multi-stripes

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

[1] Incoatec GmbH, Max-Planck-Str. 2, 21502 Geesthacht, Germany, [2] GKSS Research Centre, Max-Planck-Str. 1, 21502 Geesthacht, Germany

Introduction

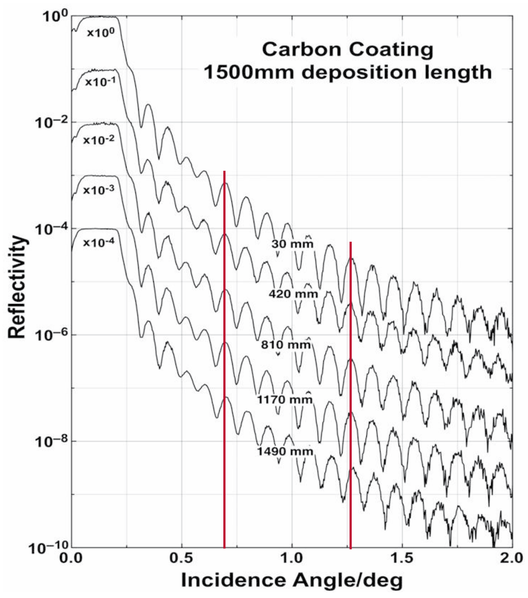
Here, we give an overview on current developments in the coating of large total reflection X-ray optics up to 150 cm in length, multilayer coatings up to 50 cm, multi-stripe multilayer optics for tomography beamlines and Montel optics (nested KB) for Synchrotron applications.

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 100 cm and longer are needed.

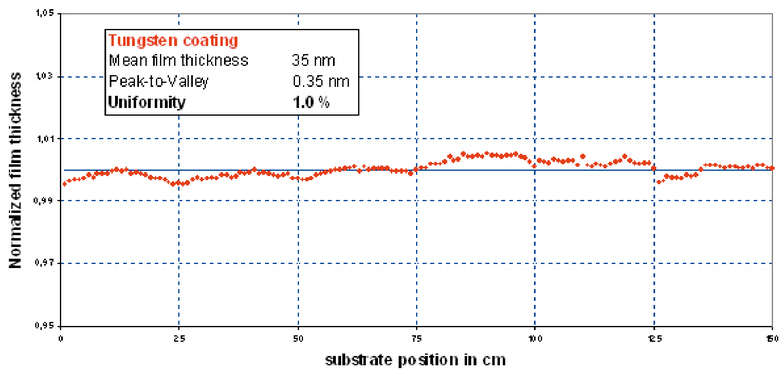
100 cm Si mirror with special carbon coating (left) and 2 substrates -110cm- on the carriage (right).

A new sputtering system for the deposition of single- and multilayers has been installed at the GKSS research centre. 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.



XRR measurement of a C-film over 150 cm length, measured by: M. Störmer

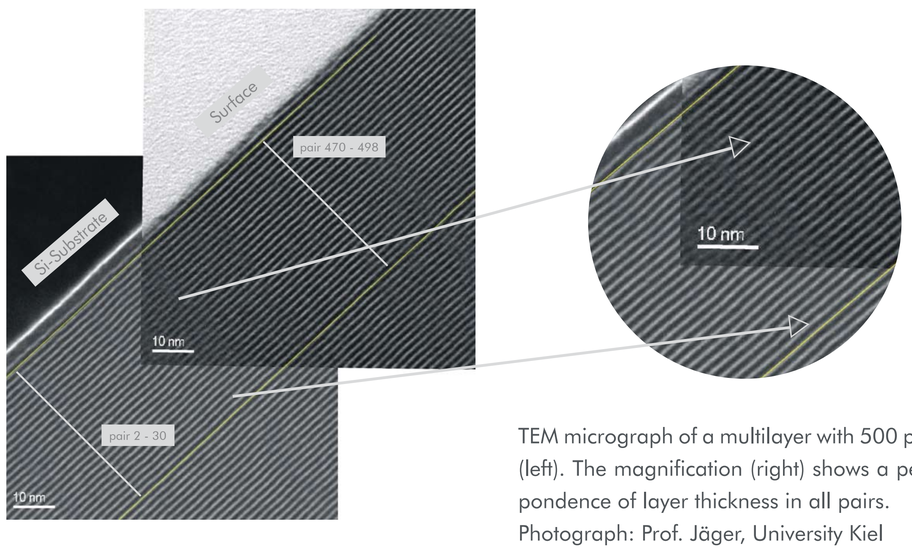
Uniformity of a 35 nm tungsten coating over 150 cm



Uniformity of thickness over 150 cm is better than 1%

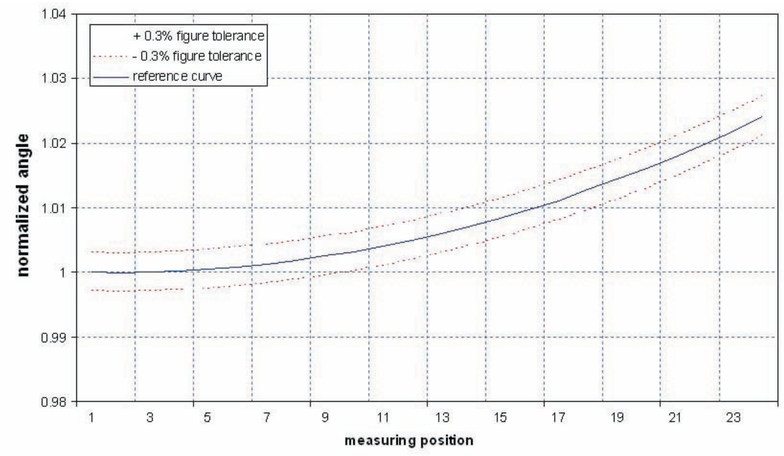
Multilayer Coating

We have experience with over 40 material combinations for example Ru/C, W/Si, La/B_4C, Mo/B_4C, ... We are able to deposit thin films with uniformities up to 0.1% as well as all kinds of gradients. The transmission electron microscopy micrograph shows a 500 pair multilayer coating with a single layer thickness of 0.7 nm. The magnification shows a perfect correspondence of the layer thickness in all 500 pairs.



TEM micrograph of a multilayer with 500 pairs of layers (left). The magnification (right) shows a perfect correspondence of layer thickness in all pairs.
Photograph: Prof. Jäger, University Kiel

500 mm Multilayer Coating with 200 Pairs



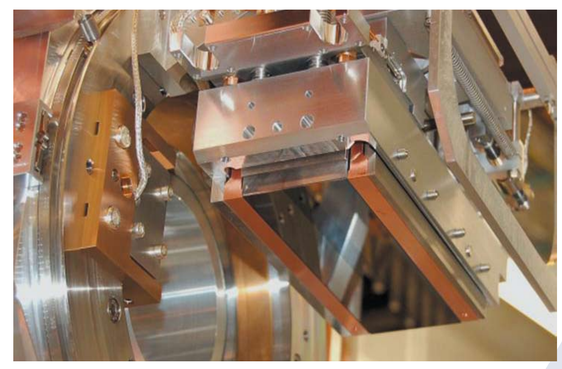
The diagram shows a graded multilayer coating over 500 mm. The deviation of the desired shape in the longitudinal direction is less than ±0.3 %. First optics were sold to the US.

Multi-stripe Multilayer Optics

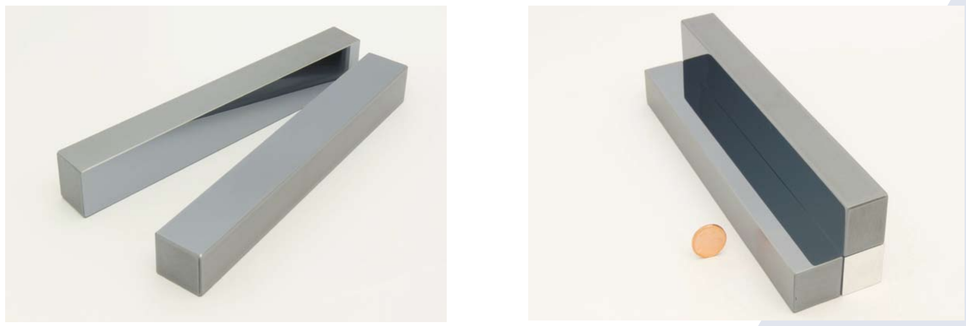
At imaging beamlines multilayer optics are often used as double crystal multilayer monochromators (DCMM). For example, tomography needs a homogeneous and stable beam profile, in order to perform optimal background corrections. Because of the high coherence of radiation, the optical components must be 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.

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

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



Montel optics for Synchrotron applications



The left picture shows the two mirror parts of a Montel optic. The right picture shows the mounted Montel optics without apertures. The slope error with < 2 arcsec is up to 5 times better than for lab-optics. The first two optics were sold to NSLS and Diamond for scattering experiments.

References

In closed cooperation with GKSS, 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 • Ellettra • Hasylab at Desy • Horiba Jobin-Yvon • Jenoptik AG • Lyncean Tech. Inc. • NSLS • 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

GKSS FORSCHUNGSZENTRUM in der HELMHOLTZ GEMEINSCHAFT

www.incoatec.de
hertlein@incoatec.de