Thin film based Optical Elements for Analytical X-ray Applications

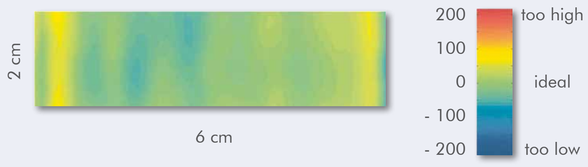
Jörg Wiesmann[1], Uwe Heidorn[1], Frank Hertlein[1], Uwe Heidorn[1], Carsten Michaelsen[1], Michael Störmer[2]

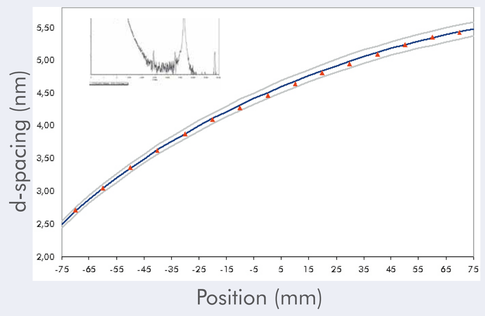
[1] Incoatec GmbH, Max-Planck-Str. 2, 21502 Geesthacht, Germany, [2] Helmholtz-Zentrum Geesthacht, Max-Planck-Str. 1, 21502 Geesthacht, Germany

Here, we give an overview on current developments in large-scale coating of total reflection X-ray optics up to 1500 mm in length, multilayer coatings up to 500 mm, multi-stripe multilayer optics, Montel optics (nested Kirkpatrick Baez geometry) for Synchrotron applications and for microfocus high brilliance x-ray sources in the home-lab.

Multilayer Mirrors for Home Lab Sources and Synchrotrons

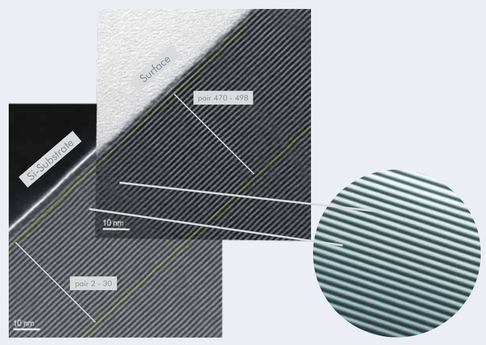
Incoatec designs and manufactures X-ray optics with properties, which are optimized for individual applications. The multilayer materials, the layer thickness profile and the substrate shape are designed by simulation with ray tracing methods. Our X-ray optics for lab instruments consist of graded multilayers which are deposited by magnetron sputtering. The precision is usually within ± 1% of the *d* spacing for standard optics and up to of ±0.2 % for high performance mirrors.





Profilometry measurement (Peak-to-Valley plot) of a parabolic substrate with a shape deviation within +/- 100 nm and slope errors below 1 arcsec (above). Typical layer pair thickness for a graded multilayer mirror showing a d-spacing gradient deviation of < 1%, measured by X-ray reflectometry (right).

As standard substrates bent silicon wafers are used which are glued onto backing plates and show slope errors of about 5-10 arcsec. For high-end applications (e.g. high resolution XRD, synchrotron applications, applications with high brightness microfocus sources), we use prefigured substrates which achieve slope errors below 1 arcsec. By combining different methods (ray tracing, profilometry, X-ray reflectometry, X-ray diffraction) at all stages of the mirror production, we have full control over the beam properties, such as beam shape, beam cross section and flux density. During the development phase of multilayer optics the method TEM (transmission electron microscopy) is applied.

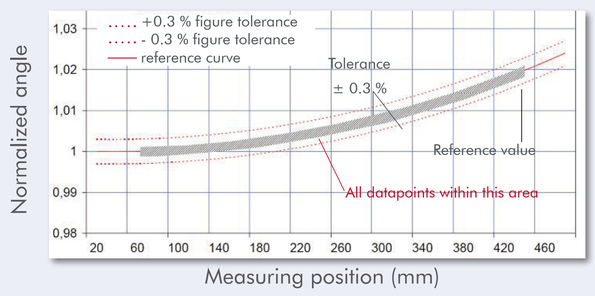


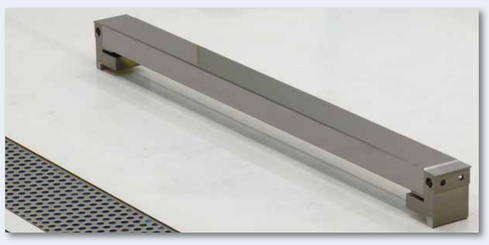
TEM image of a multilayer with 500 pairs of layers. The magnification shows a perfect matching of the layer thickness throughout all pairs. (Prof. Jäger, University of Kiel)

Synchrotron Optics

Incoatec offers different types of X-ray optics for synchrotron and XFEL applications. In our deposition facilities, we can coat substrates of up to 150 cm in length and have experience with more than 40 different types of layer materials.

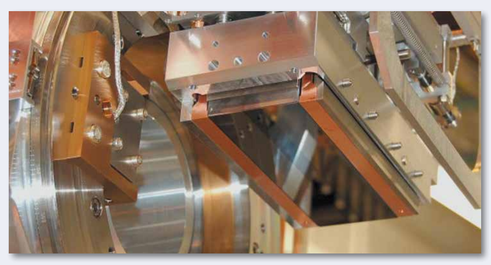
50 cm Graded Multilayer Coating with 200 Pairs





Bendable 400 mm silicon mirror

Multi-stripe Multilayer Optics



Three-striped multilayer optics for tomographic microscopy and coherent radiology (TOMCAT at SLS; M. Stampanoni, PSI).

Stripe A: *[Ru/C]100, d=40 Å, y=0.5, R > 80 % for 10<E<22keV*

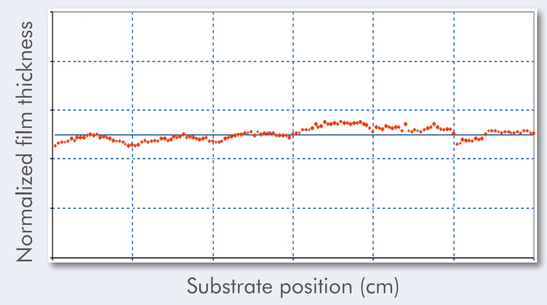
Midspace: *Si<111>, roughness 0.1 nm, slope error 0.04“*

Stripe B: *[W/Si]100, d=30 Å, y=0.5, R > 80 % for 22<E<45keV*

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.

A 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.

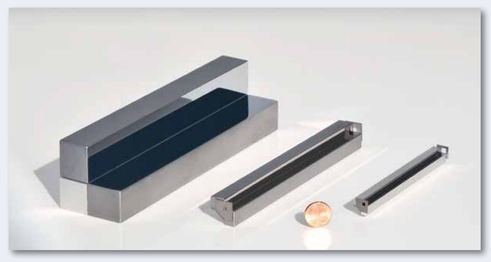


Tungsten coating	
deposition length	*1500 mm*
Mean film thickness	*35 nm*
Peak-to-Valley	*0.35 nm*
Uniformity	***1.0 %***

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

Beam Shaping in 2D with Montel Optics

Montel optics consist of two mirros mounted side-by-side in an L-shape enabling a 2-dimensional beam shaping. A Montel optics with two elliptically shaped mirrors is point focusing, whereas two parabolic mirrors enable a collimated beam. A line focus is created with a hybrid optics, a combination of an elliptic and a parabolic mirror. The quality of the beam shaping due to the optics is demonstrated by the beam properties in the focus. The Montel optics accumulate a lot of flux within a well-shaped, gaussian-like spot of expected size measured by 2D detectors or pin diodes. Nowadays, Montel optics are also used at synchrotrons, where they substitute the KB (Kirkpatrick-Baez) mirrors achieving a more compact design.



Montel Optics - 10-15 cm in length

Different cross sections from 4 x 4 cm to 1 x 1 cm; some were sold to NSLS and DLS. They are used at inelastic scattering beamlines.

References

In close cooperation with HZG, Incoatec has produced 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.

APS · Bessy · Diamond · Elettra · Desy - XFEL · Lyncean Tech. Inc. · NSLS · PAL · SLS-PSI

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Conclusion

- Multilayer coatings up to 50 cm
- New Montel optics for high-brilliance sources
- Montel optics for Synchrotron applications
- Multi-stripe multilayer optics as monochromators

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

Incoatec Microfocus Source IμS for X-ray Diffraction

The IμS is a low power air cooled X-ray source for diffractometry applications. The source is equipped with a Montel optics. Therefore, we can form either a highly collimated beam with a low divergence (below 0.5 mrad) or a focusing beam with higher divergence (up to 10 mrad) and very small focal spots at the sample (diameters downto 100 μm). The Cu-IμS with collimating optics can be used for (GI)SAXS and X-ray diffraction studies. With focusing optics experiments can be carried out in transmission geometry, especially in powder diffraction applications. With the Mo- and Ag-IμS highly absorbing and radiation-damage sensitive materials can be investigated. Consequently, these sources are often used for chemical crystallography and become more and more interesting for investigation of soft matter samples or for XRD measurements during the growth of nanosized materials.

More about applications of IμS
“Determination of growth quality of thin films by In-situ GISAXS during the deposition process“
by J. Wiesmann — talk CIA 8238
Thursday July 14 4:45pm

Upgrading Existing Diffractometers with the Microfocus Source IμS

You have a Bruker AXS, Marresearch, Nonius, Rigaku, Huber or some other system?

Incoatec offers a unique possibility to upgrade your existing diffractometer by installing the high-performance, air-cooled and low-power microfocus source IμS.

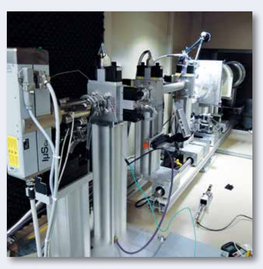
Your upgrade benefits:

- No maintenance, only single phase power and no water cooling required
- 3 years warranty
- Maximum installation down time of only 2-4 days
- Full integration into existing safety circuits for Bruker equipment, new safety concept development on request
- Full compliance with European Machinery Directive 2006/42/EC

Your upgrade options:

- Source, optics and scatterliss slits
- Single source upgrade for XRD, SCD, (GI)SAXS, XRR and many more applications
- Dual wavelength setup by adding IμS as complementary source
- Cu, Mo, Ag, Co and Cr radiation (others on request)

IμS and SCATEX upgrades on SAXS systems



IμS and SCATEX upgrade on a customized SAXS setup in Hamburg

Adaptation to UHV deposition chamber for in-situ GISAXS studies in Bratislava, Slovakia

Replacement of Rigaku RU-200 generator in Boulder, USA

Huber system for SAXS in Tamkang, Taiwan

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