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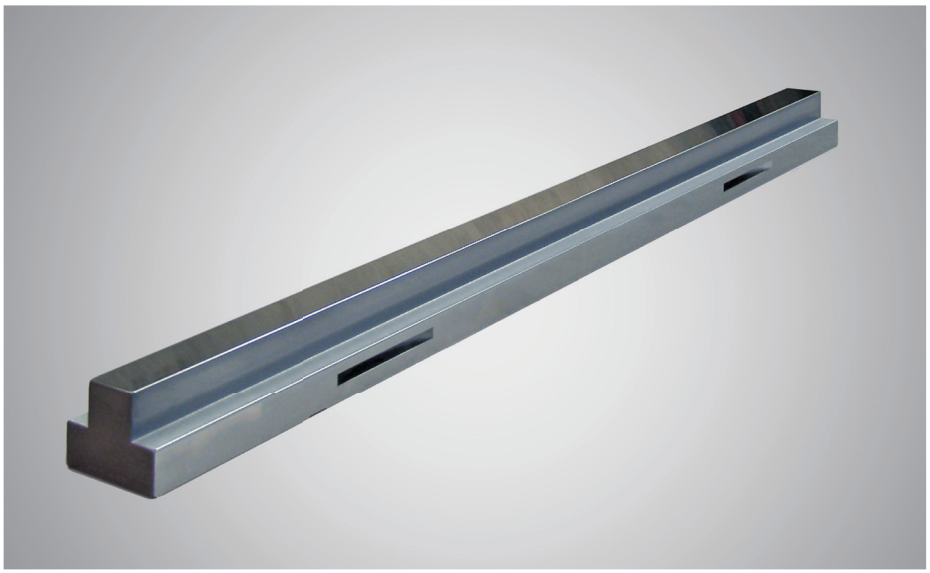
innovative coating technologies

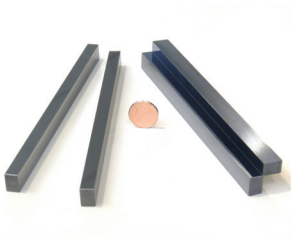
Synchrotron Mirrors

Thin films with a length of up to 150 cm

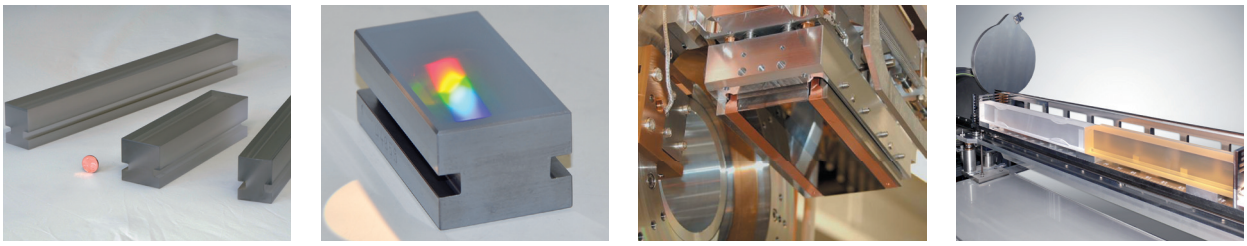


Si-mirror with a length of 100 cm

Double crystal multilayer monochromators



Montel optics



Various coated substrates: silicon - fused silica – Zerodur®, plan or 1D and 2D curved - gratings

Incoatec offers thin film coatings for all kinds of synchrotron optics for beam guidance, beam shaping and other beamline experiments.
Our unique possibilities in deposition techniques allow us to produce single layer and multilayer coatings up to 150 cm in length with a large variety of material combinations and designs.
Together with our synchrotron business partners we also offer a wide range of complete optics solutions such as:

- Double crystal multistripe multilayer monochromators
- 1D and 2D curved optics
- Total reflection optics
- 2D focusing, collimating or hybrid Montel optics
- Coating for gratings

You have new requirements for optics or need coatings?

We like to be challenged!

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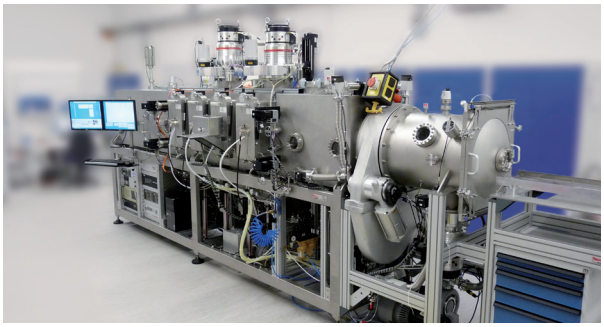
Deposition and Characterization

Layer deposition

We have experience with a lot of material combinations for single layer or multilayer coatings, e.g.: C, B_4C, BN, SiC, Sc, Ti, V, Cr, Ni, Ge, Mo, Ru, Rh, Pd, La, Ta, W, PT, Au, Ru/C, Cr/B_4C, W/Si, La/B_4C, Mo/B_4C, …
With our modern sputtering equipment, we are able to deposit stripes of single layer films as well as laterally and depth graded multilayers over a length of up to 150 cm.



Linear sputter coating unit with 4 different target materials

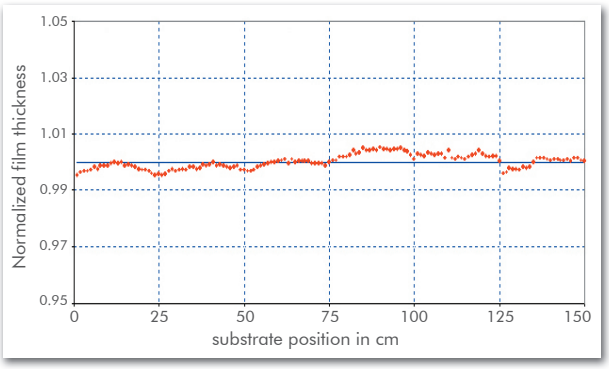
The coatings are characterized by excellent homogeneities, very good adhesion, high density, low roughness and high reflectivities.

Characterization with X-ray reflectometry

Typically, coating parameters such as layer thickness, uniformity density, roughness, reflectivity and gamma ratio for the multilayers are characterized using XRR at Cu-K_α (8048 eV) at different positions on each mirror coating.

Uniformity of a 35 nm tungsten coating over 1500 mm

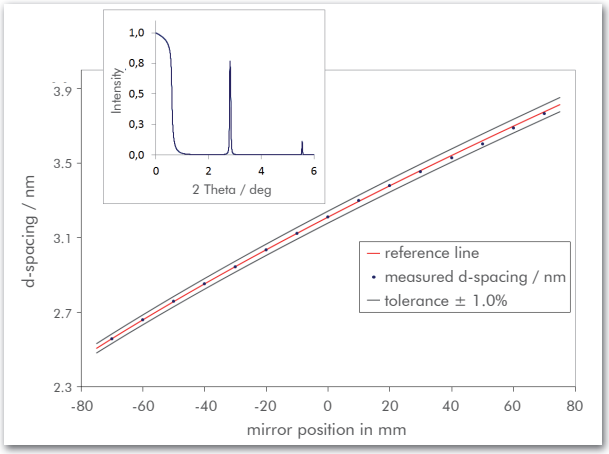
deposition length	1500 mm	Mean film thickness	35 nm
Peak-to-Valley	0.35 nm	Uniformity	1.0 %



The thickness uniformity over 150 cm is better than1%

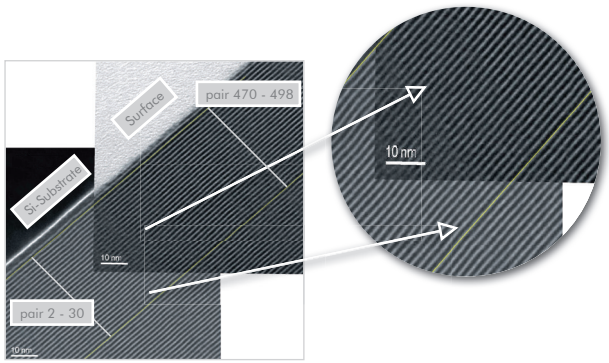
XXR measurement of a multilayer coating

Multilayer coatings are examined by means of X-ray reflectometry. The quantification of the 1st Bragg order allows the determination of the maximum of reflectivity, integral intensity and energy resolution.
The XRR measurements allow a deduction of the interface roughness and the material density of the layers. The aim of multilayer film deposition for X-ray optics is to obtain interfaces which are as sharp and smooth as possible, and to achieve optimal density contrast between single laysers. The Bragg peak angles can be used to calculate the double layer thickness period, the so-called d-spacing.



Laterally Graded Multilayer Optics: The film thickness variation along the substrate and the ideal and acceptable thickness gradients are shown.

TEM-Picture of a 500 pair multilayer coating



TEM micrograph of a 500 pair multilayer coating with a single layer thickness of 0.5 nm. The magnification shows a perfect correspondence of the layer thickness over 500 pairs.

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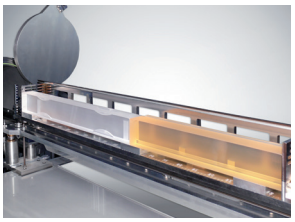
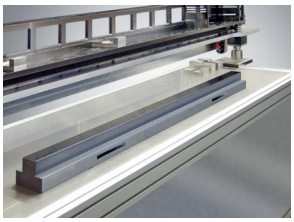
Optics for Synchrotron Applications

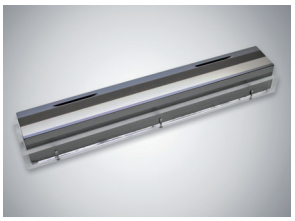
Total reflection optics

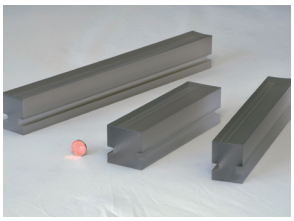
Total reflection optics are needed at synchrotron beamlines for beam guidance and beam alignment. This type of X-ray optics is used at grazing incidence angles and therefore more and more optics with lengths of 100 cm and more are required.





Various mirror substrates: 50 cm fused silica, 60 cm Zerodur®, 100 cm silicon

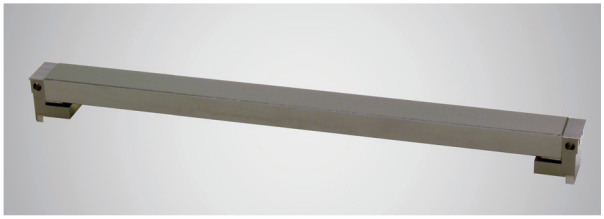




Stripe coating on a 50 cm silicon substrate

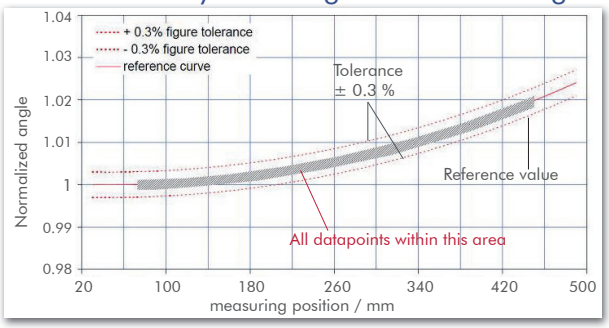
Multilayer optics

These optics consist of multilayer films which reflect X-rays using the principle of Bragg diffraction. The single layers, each one only a few nanometers thick, are amorphous. The multilayer may consist of up to several hundred layers. High reflectivity is obtained when the multilayer materials have a high density contrast and simultaneously a low absorption. The two X-ray optical properties of relevance, i.e. the absorption and dispersion, depend on the X-ray wavelength. Therefore, each wavelength requires its own particular type of multilayer, in order to achieve the best results. To get the optimum optics for a customer specific application we are able to carry out X-ray optical simulations.



Bendable 400 mm silicon multilayer optics

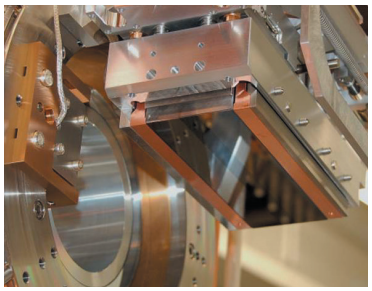
Graded multilayer coatings 500 mm in length



The deviation of the desired shape is less than ± 0.2 %.

Double crystal multilayer monochromators

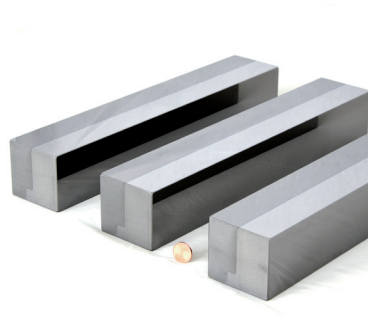
At imaging beamlines multilayer optics are often used as double crystal multilayer monochromators (DCMM). For example, in tomography a homogeneous and stable beam profile is required, in order to perform optimal background corrections. Due to the strong coherence of the radiation, particular care must be taken when designing the optics in order to avoid a deterioration in beam quality. Multilayer coatings with up to 5 stripes were produced with films homogeneities below 0.2% as well as with lateral gradients.



Stripe A:
[Ru/C]
d=40 Å, γ=0.5,
R > 80 % for 10<E<22keV
Midspace:
Si<111>
roughness 0.1 nm,
slope error 0.04“
Stripe B:
[W/Si]
d=30 Å, γ=0.5,
R > 80 % for 22<E<45keV

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

Set of three DCMM 300 mm in length



Si, orientation <0.05°
300 x 55 x 50 mm
slope error tangential:
0.25 µrad rms
slope error sagittal:
5 µrad rms
HSF Roughness < 2 Å rms

Stripe 1: Ru / C
Stripe 2: W / B4C
Period: 40 / 26 Å
Density:
Ru~10.5 g/cm³
C~2.2 g/cm³
W~17.5 g/cm³
B_4C~2.2 g/cm³
Interface Roughness 3 Å rms

Synchrotron mirrors for PAL in Korea (Operating energy range 10 – 80 KeV) 300 mm in length

Synchrotron

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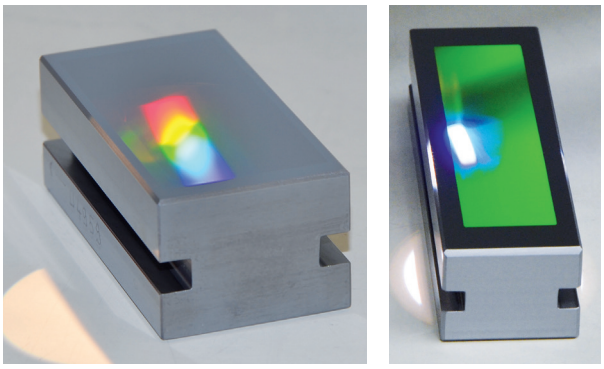
Coated Gratings

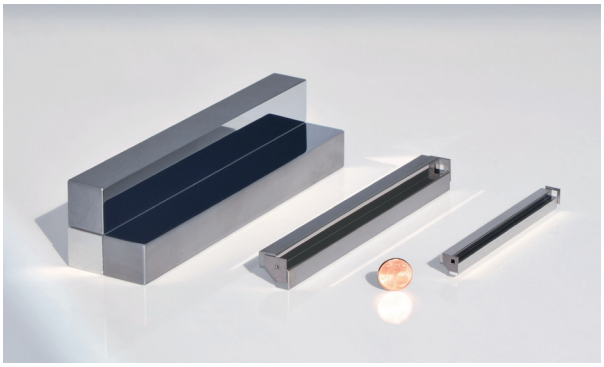
To enhance the grating efficiency in the spectral range from IR to UV, single layer coatings as Al, Ni, Pt, Cr/Au are in commend used. For specific VUV and soft X-ray applications, high density coatings such as carbon or SiC are widely used. Due to our sophisticated deposition technique we are able to offer you these type of coatings with excellent adhesion.



Gratings coated with SiC for better reflectivity

Montel Optics for Synchrotron Beamlines

3rd Generation Montel Optics with slope errors < 2 arcsec are used at Synchrotron beamlines in analyzer systems for inelastic scattering experiments. First optics with this type of small slope errors were sold to NSLS and Diamond for scattering experiments. Montel optics with similar qualities are known from the latest lab-instruments like a Liquid Metal Jet Source.



Montel Optics - 100-150 mm in length - with different cross sections from 40 x 40 mm to 10x10 mm

Our mirrors are custom-made!

Incoatec offers total reflection optics consisting of highly-stable carbon, silicon carbide, tungsten, ruthenium or other materials, multilayer coatings up to 500 mm as well as multi-stripe optics. Many research centers worldwide use our know-how and our optics.

Our thin film optics are characterized by:

- low figure error
- low roughness
- high reflectivity
- high stability and high damage threshold

Contact and challenge us!

www.incoatec.de/synchrotron

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