State-of-the-art thin film X-ray optics for synchrotrons and FEL sources

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Incoatec: Innovative Coating Technologies

- Incoatec is founded with Bruker AXS in 2002
- Own R&D activities and application lab
- over 12 years of experience in X-ray optics and over 18 years of experience in thin film technology
Outline

- Products & Services
- Multilayer coating
- Deposition of thin films
- Characterization
- Applications
  - Total reflection optic for FEL
  - Multi-stripe optic for Tomography Beamline
- Conclusion
Products & Services

- Multilayer mirrors
- Customized coatings for synchrotron mirrors and other applications
- Incoatec Microfocus Source IμS™
- Upgrades of existing equipment
Products:
Incoatec Microfocus Source – IµS

- High brilliance low-power microfocus source
- For Cu or Mo
- Air-cooled
- New type of 2D beam shaping Montel Optics: The Quazar™ Optics
- New easy-to-align housing, optional with motors
- Low maintenance
- Tube change as easy as for conventional sealed-tubes
- 3 Years warranty

High performance at only 30 W
Products: Multilayer Mirrors

- XRD
- SCD
- XRF
- Synchrotron

Göbel Mirror
Montel Mirror
XRF - Multilayer Analysator
Coating of Synchrotron Mirror up to 150 cm
Products: X-ray Optics for Synchrotron Beamlines

Typical mirror substrate materials:
Fused Silica, Zerodur, Silicon, …

- **Special Carbon Coatings**: for High Flux Beamlines like FEL at DESY
- **Multilayer (Stripes) Coatings**: optimized for the most different applications, dimensions and shapes
- **Cooperation with GKSS**: R&D for film and deposition technology

Mirrors up to 150 cm length!

We produce the coating for your optic as you like!
Deposition by Magnetron Sputtering

Optimized deposition facilities for different sizes, gradients and precisions

Argon Plasma
Deposition of Thin Films

Magnetron Sputtering

- Monolayer, Multilayer, Graded-Multilayer, Stripe-Multilayer

- area for deposition:
  - up to 150 x 12 x 12 cm
  - or 6” diameter

- film thickness: single layer 1..500 nm

- Precision: typical ±1%, up to ±0.1%
Requirement for coating

- good homogeneity over the whole mirror, up to 0.2%
- exact d-spacing over the whole stack, with up to several hundred pairs
- low roughness, better than 0.3 nm
- sharp interfaces, none interdiffusion
TEM-Picture of a multilayer coating

Perfect correspondence of the layer-thickness over 500 pairs

500 pairs  $d = 1.4\ \text{nm}$
Characterization with XRR

Bruker D8
with 5 DOF
motorized table

Substrates up to 30 x 30 x 6 cm³
Characterization with XRR

Graded Multilayer Characterization with XRR

Tolerance ±1%
Reference value
Datapoint

d-spacing accuracy better 1%!
Characterization with SFM / AFM

Research & Development:

SFM
Scanning Force Microscope

AFM
Atomic Force Microscope

C-Film (38 nm) on Silicon

Rq,rms = 0.24±0.02 nm
Application I: Total reflection optics of carbon for FEL

Optics for FEL at Desy
Substrate made by: ZEISS
Coating made by: INCOATEC

Reflectivity vs. Energy measured by B. Steeg, Hasylab

- amorphous carbon layer, \( d=38 \text{ nm}, \sigma = 1.27 \text{ nm} \)
- simulation by IMD for diamond, \( \rho = 3.5 \text{ g/cm}^3 \), \( d=38 \text{ nm}, \sigma = 0 \text{ nm} \)

R(E) \( \sim 95-96\% \) at 50 - 250 eV at grazing incidence of 2 deg
Characterization of Total Reflection Optics

XRR measurement with Cu-K$_\alpha$ (8 keV) at different positions

density: 2.2 g/cm$^3$
roughness: 0.5 nm
thickness: 44.2 nm

Measured by M. Störmer, GKSS
Characterization of Total Reflection Optics

Mean film thickness
44.2 nm

Standard deviation
0.2 nm rms

Peak-to-Valley
~1 nm

Homogeneity
better 2%

Measured by M. Störmer,
GKSS Forschungszentrum

150 cm Carbon Coating on Si-Substrate

SPIE proceeding 2008 7077/4

XRR at 27 positions
Application II: Multi-stripe X-ray Optics

Tomography Beamline (M. Stamppanoni, PSI-SLS)

Substrate made by:

Coating made by:

Stripe A: $[\text{Ru/C}]_{100}$, $d = 40 \text{ Å}$, $\gamma = 0.5$, $R > 80\%$ for $10 < \text{E} < 22 \text{ keV}$
Midspace: Si111, $D_{\text{orientation}} < 0.01^\circ$, $\sigma = 0.1 \text{ nm}$, slope error $0.04''$
Stripe B: $[\text{W/Si}]_{100}$, $d = 30 \text{ Å}$, $\gamma = 0.5$, $R > 80\%$ for $22 < \text{E} < 45 \text{ keV}$

Picture courtesy of M. Stamppanoni, PSI-SLS

Coating made by:

Substrate made by:

INCOATEC

GKSS

ZEISS
Conclusion - Our profile

• Simulation of layer and optics properties
  - Flexible, on customer request

• Physical Vapour Deposition (PVD) methods for coatings
  - extreme precise coatings
  - large area coatings
  - with gradients / stripes / monolayer / multilayer

• Characterization of thin films

We produce the optics as you like!
Flexible “in-house” manufacturing for various wavelengths and applications
Conclusion - Our costumers

- Zeiss
- JenOptik
- Desy / Hasylab
- Bessy
- University of Hamburg
- University Göttingen
- APS / ANL
- Swiss Light Source PSI
- SESO
- ...
Thank you for your attention