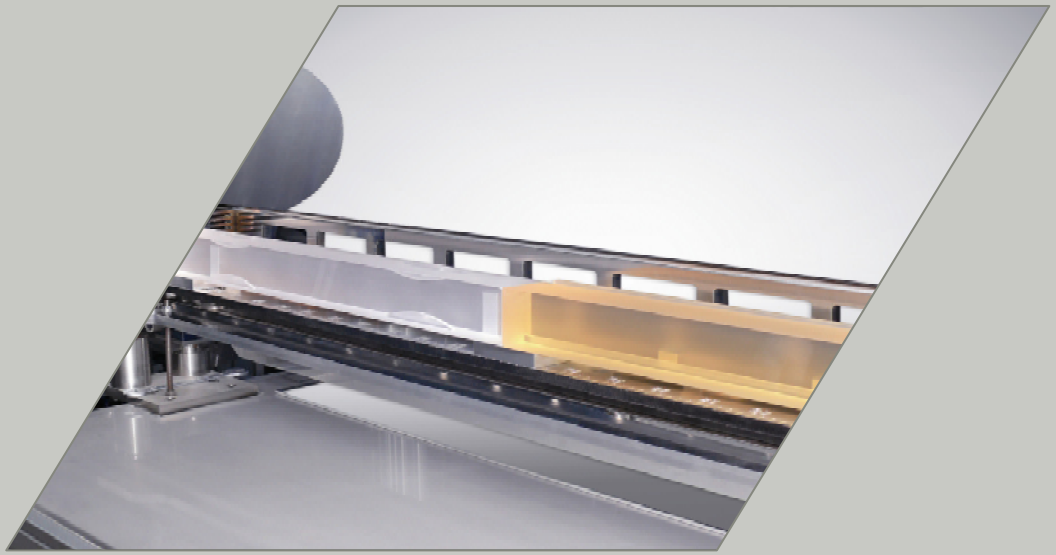
INCOATEC
innovative coating technologies gmbh

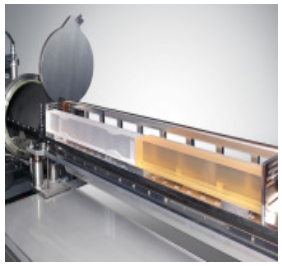
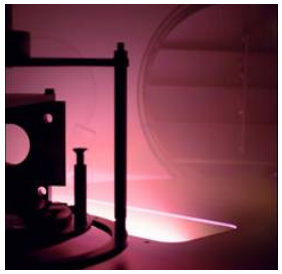


Trends on X-ray Optics for Synchrotron Beamlines

ACTOP 2011

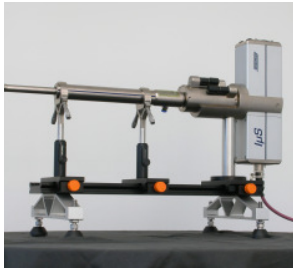
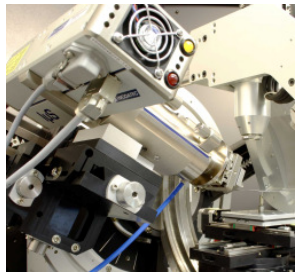
Uwe Heidorn
- Incoatec GmbH- Geesthacht, Germany

Incoatec:
Innovative Coating Technologies

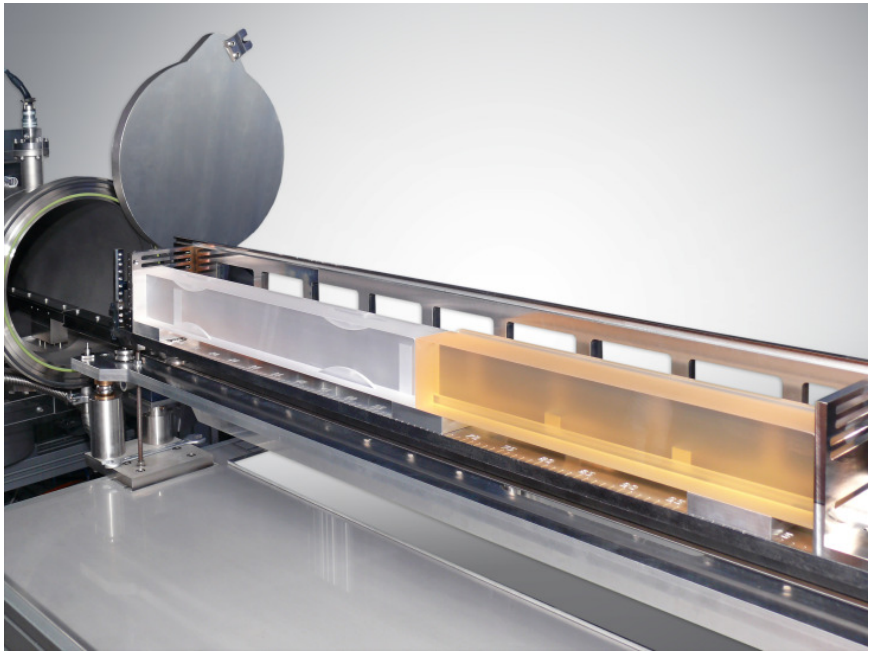





- Spin-off of GKSS Research Center (now HZG) in Geesthacht near Hamburg
- Close partnerships with Bruker ASC (former Accel) and ZEISS
- Production & development of X-ray optics and microfocus sources



Synchrotron Optics



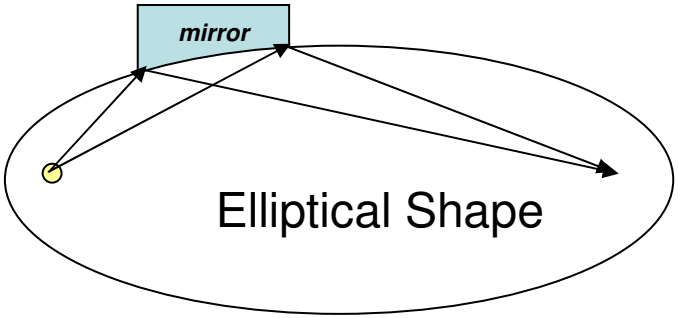
- Thin film deposition
- Multilayers
- Multi stripe coatings
- Total reflection coatings
- Special solutions for FEL

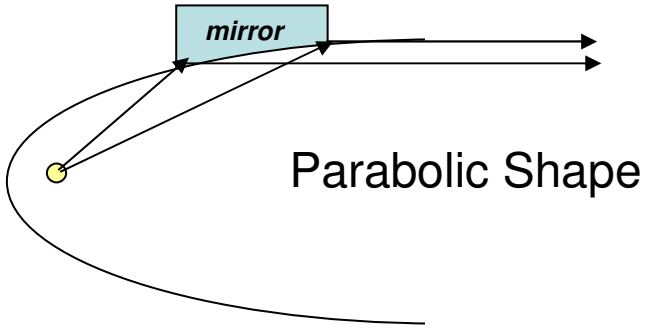
Content

1. Substrates and coatings
2. Layer - Deposition
3. Characterization of X-Ray optics
4. Applications
5. Conclusion

1. Substrates and coatings

Different kinds of substrate shapes





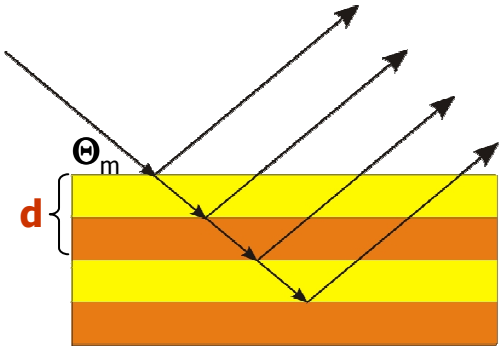
Substrates:

- "Curved and glued" wafers
  (slope errors down to 5 arcsec)
- Prefigured substrates
  (slope errors down to 0.2 arcsec)
- Low roughness
  (down to 1 Å)

1. Substrates and coatings

Gradient coatings for X-ray monochromatisation

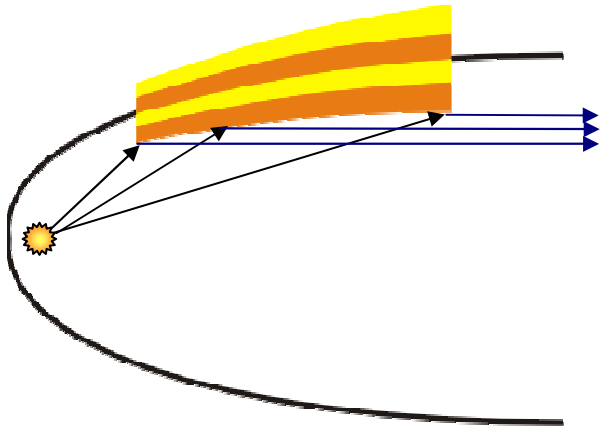
scattering on a multilayer



$$m \cdot \lambda = 2 \cdot \mathbf{d} \cdot \sin \Theta_m \cdot \sqrt{1 - \frac{2\delta - \delta^2}{\sin^2 \Theta_m}}$$

graded multilayer

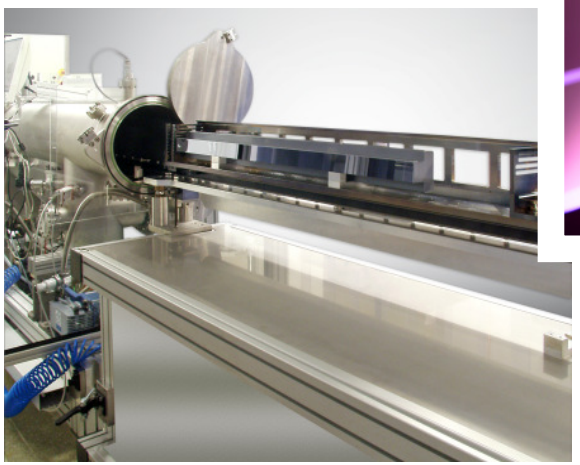
different angles of incidence



- Mirror is adjusted at the first Bragg order
- Graded multilayer for high reflectivity and monochromatization in every point of the mirror

2. Layer-Deposition

Magnetron sputtering



Optimized deposition facilities
for different sizes, gradients and precisions

2. Layer-Deposition

Magnetron sputtering

Target materials:

for Total Reflection:

C, B_4C, SiC, SiN, Rh, Ru, W, Cr, ...

ML-Reflector:

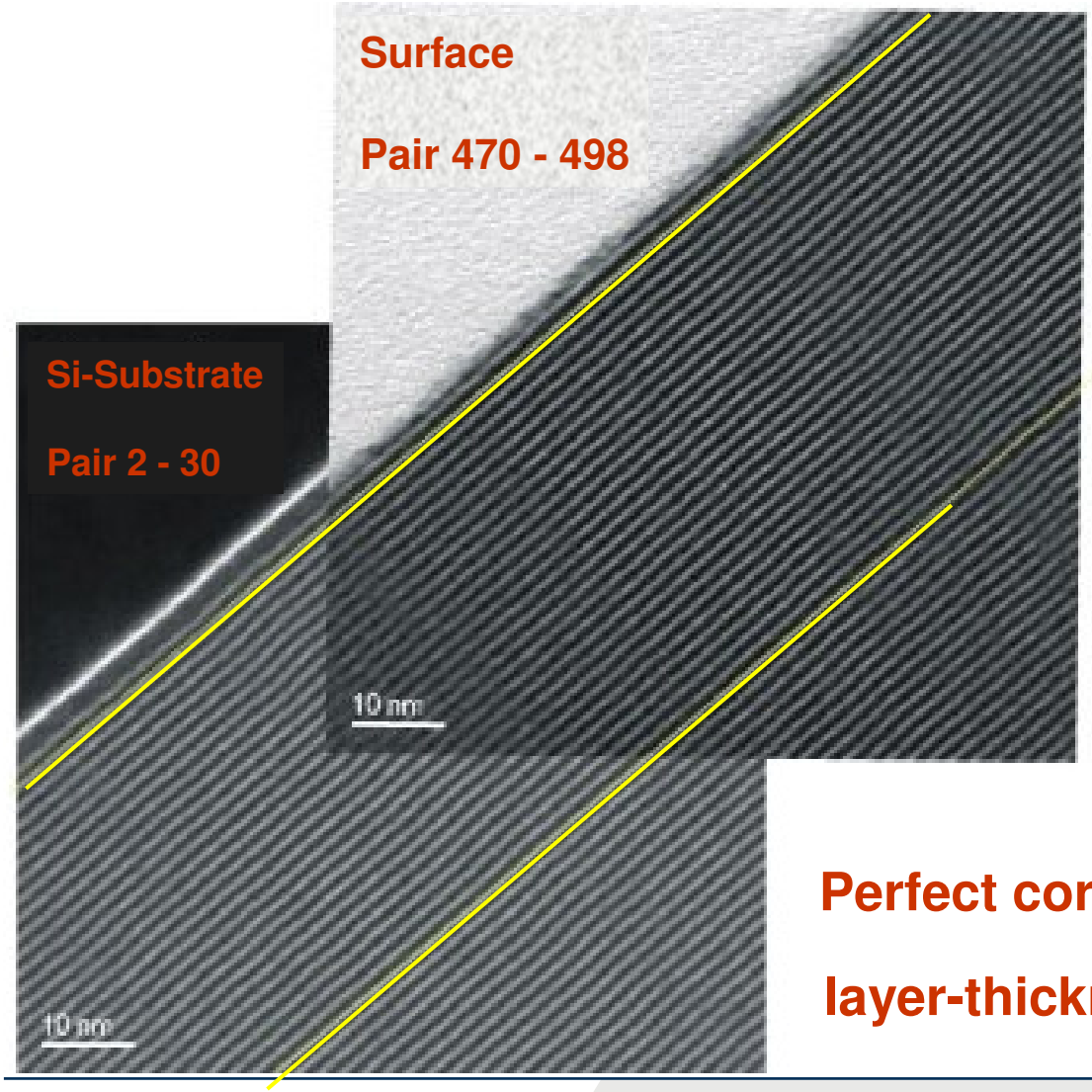
W, WSi_2, Ru, V, La, Mo, TiO_2, Ni …

ML-Spacer:

C, BN, B_4C, Si,…

2. Layer-Deposition

TEM – Picture of a multilayer coating -



500 pairs d = 1.4 nm

Perfect correspondence of the layer-thickness over 500 pairs

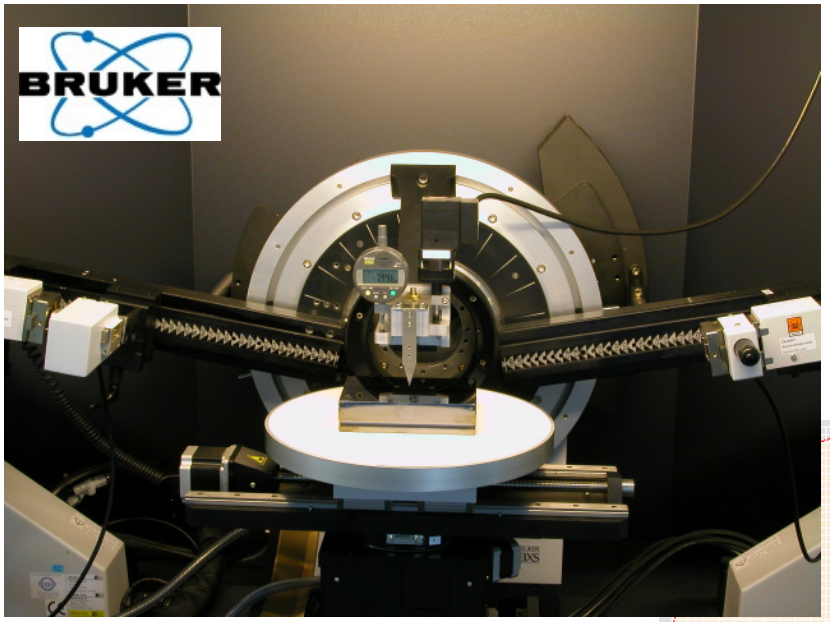
2. Layer-Deposition

Requirements for coatings

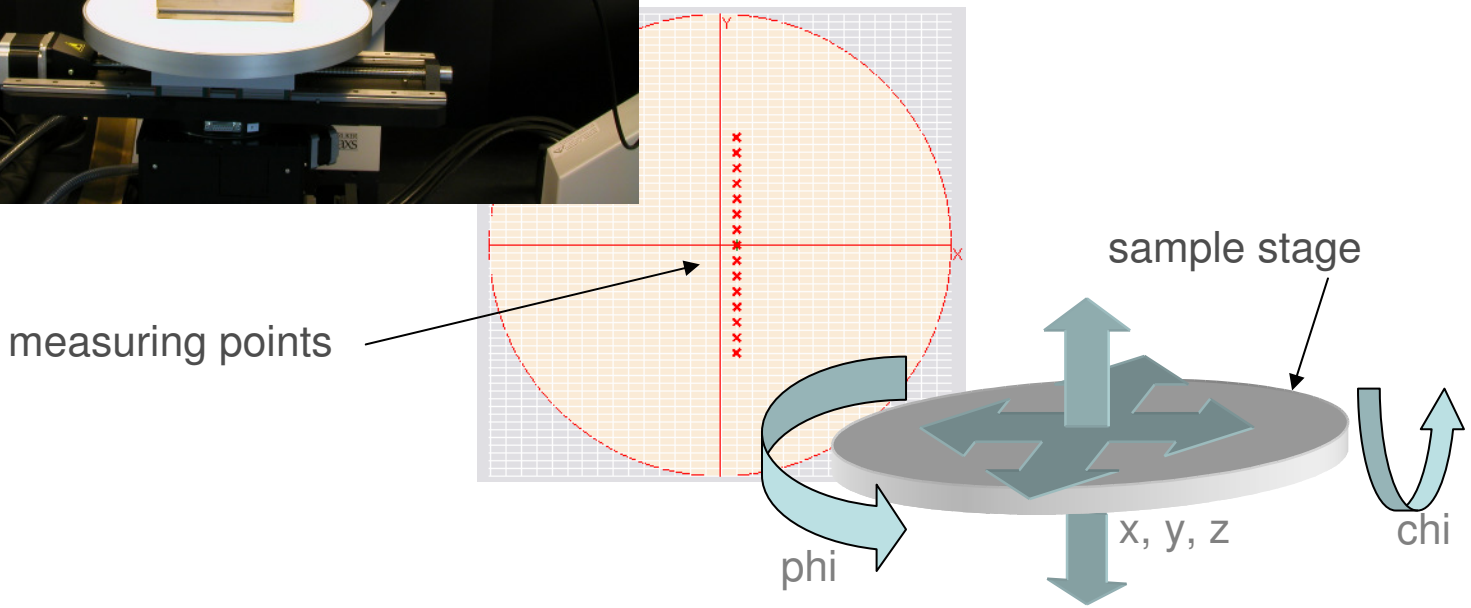
- Good homogeneity over the whole mirror, up to 0.2%
- Exact d-spacing over the whole stack, with up to several hundred pairs
- Low roughness, better than 0.3 nm
- Sharp interfaces, none interdiffusion

3. Characterization of X-Ray optics

Diffractometer for XRR

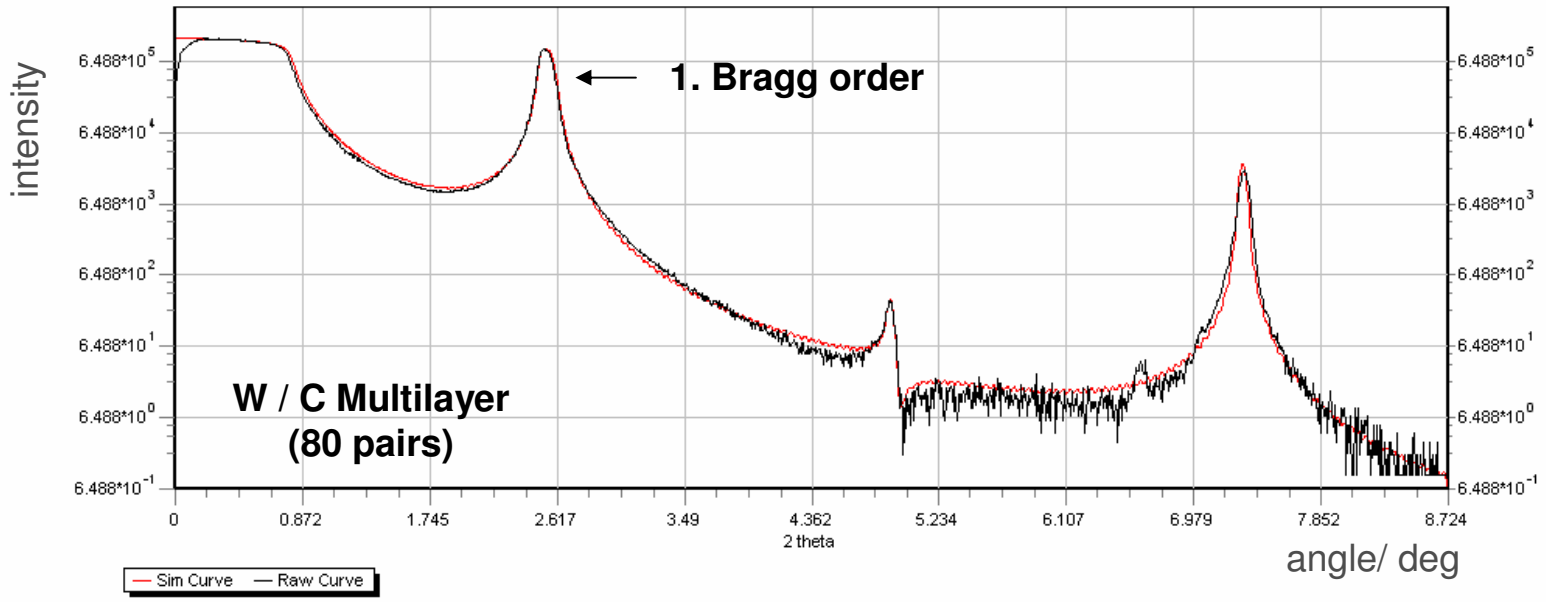


- D8 from Bruker AXS
- Motorized table
- Full automatic measurement



3. Characterization of X-Ray optics

Simulation of XRR-measurements



Results:

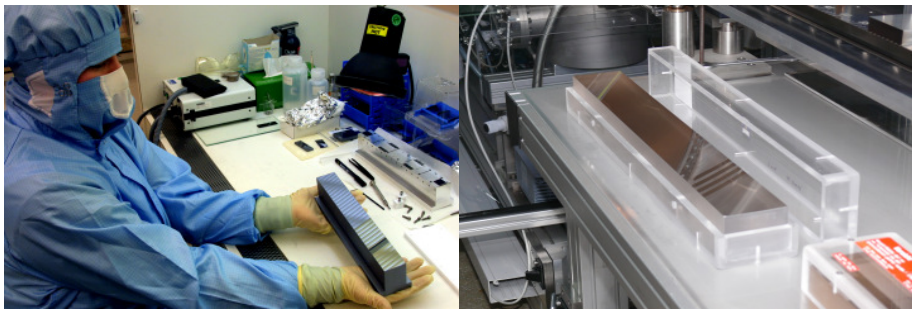
- Layer-thickness
- Reflectivity
- Roughness
- Densities

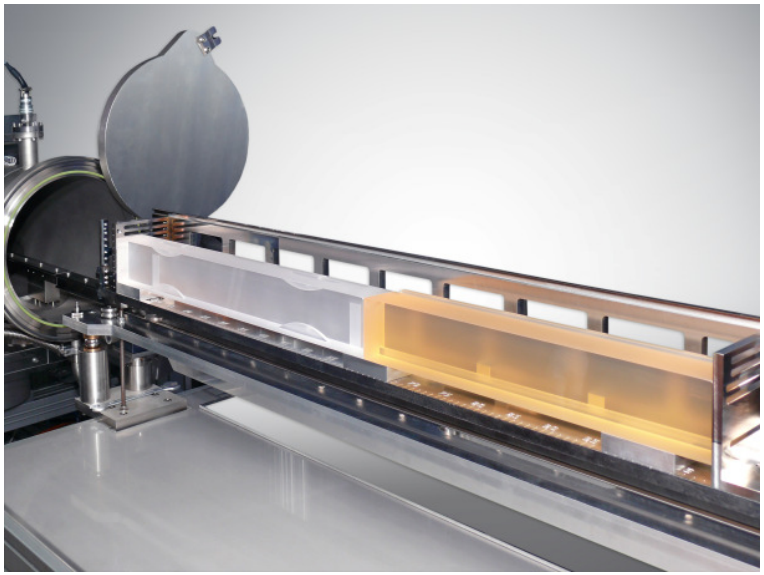
3. Characterization of X-Ray optics

for Synchrotron Beamlines

Typical mirror substrate materials:

Fused Silica, Zerodur, Silicon





Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

- **Cooperation with HZG:**

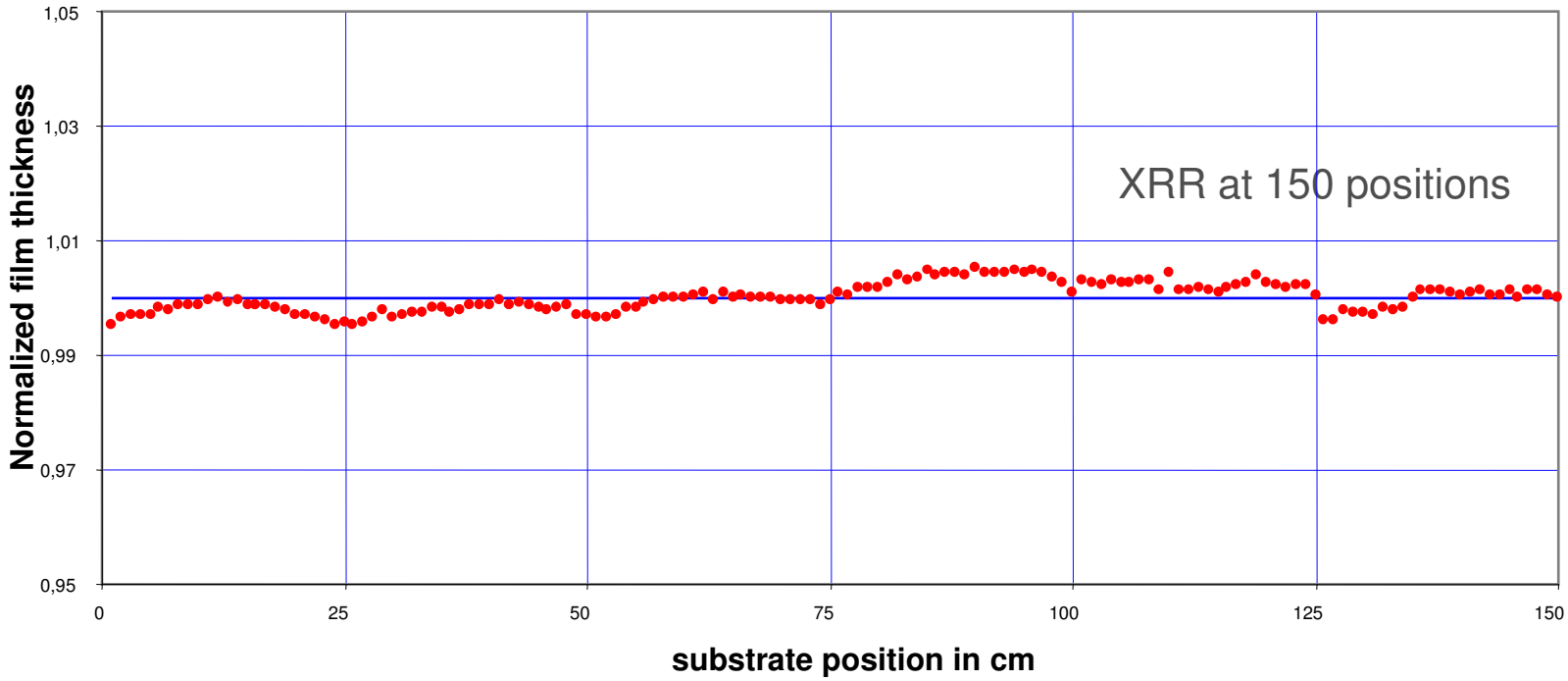
  R&D for thin film deposition technology

Single-Layer coatings up to 150 cm in length!

3. Characterization of X-Ray optics

Homogeneity of Single-Layers

150 cm Tungsten Coating on Si-Substrate



Mean film thickness
35 nm

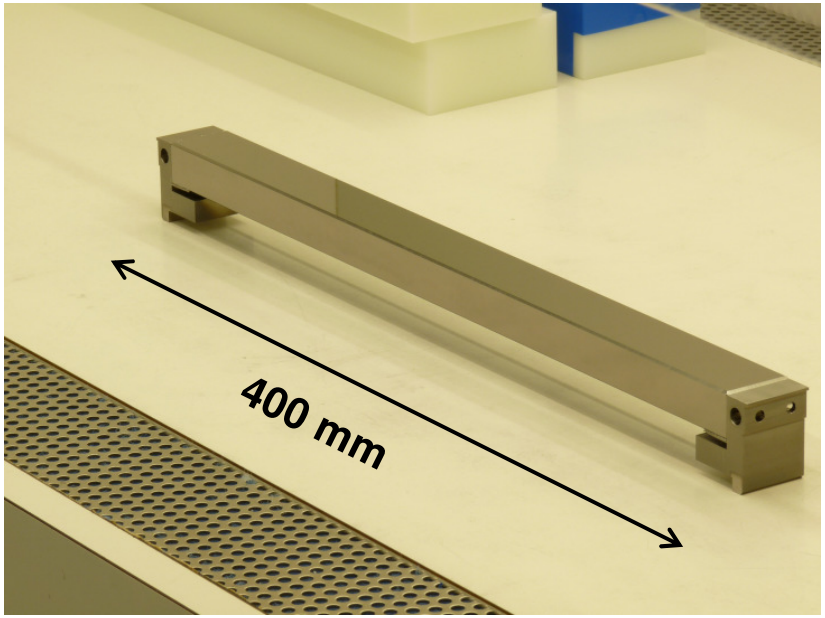
Peak-to-Valley
~0.35 nm

Homogeneity
about 1.0 %

3. Characterization of X-Ray optics

Bendable multilayer optic

Silicon mirror
with graded multilayer coating



200 pairs

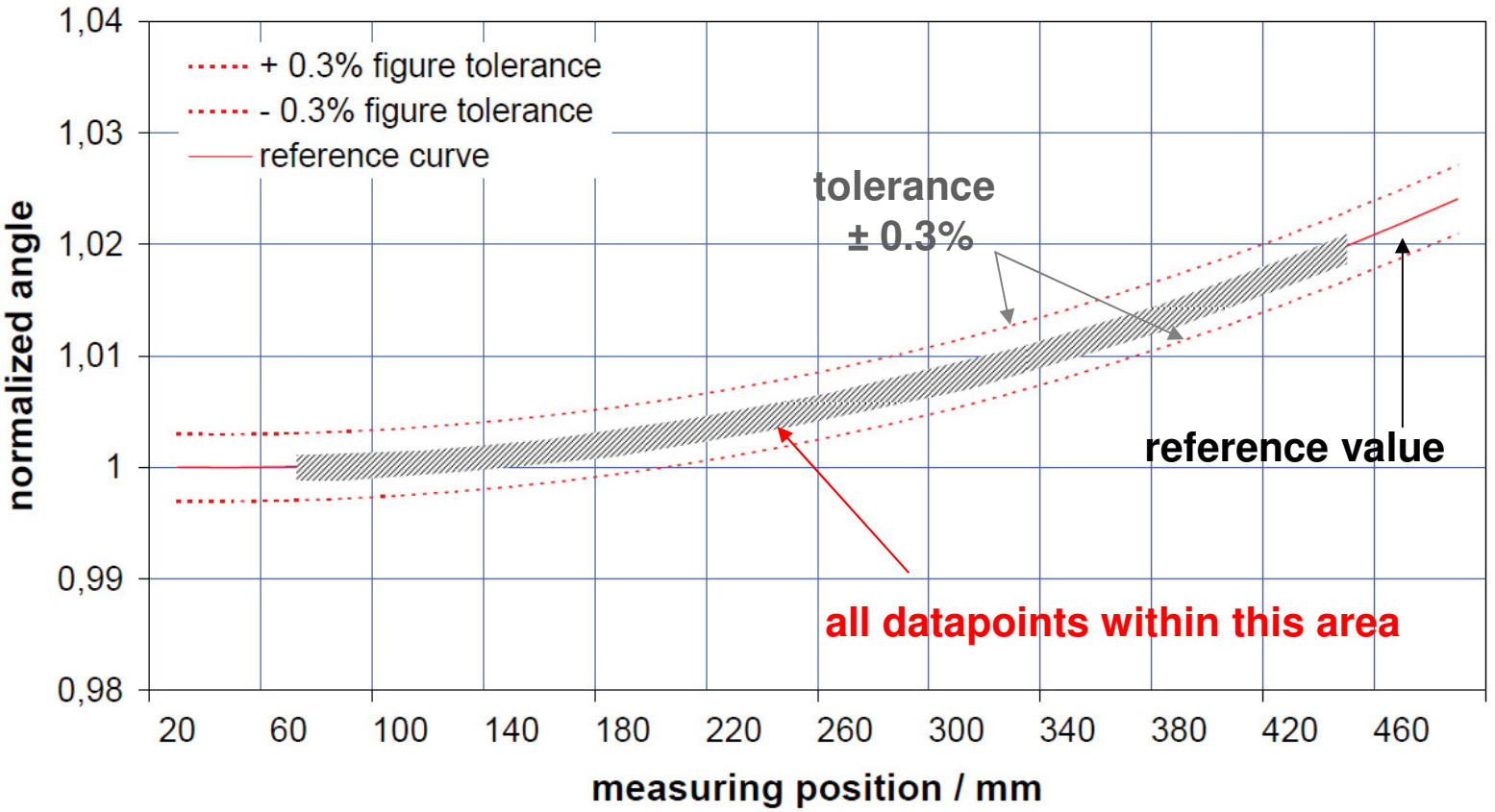
Ru / C Multilayer

for 7.0 – 20.0 keV

Multilayer coating up to 500 mm in length!

3. Characterization of X-Ray optics

Graded Multilayer Characterization with XRR

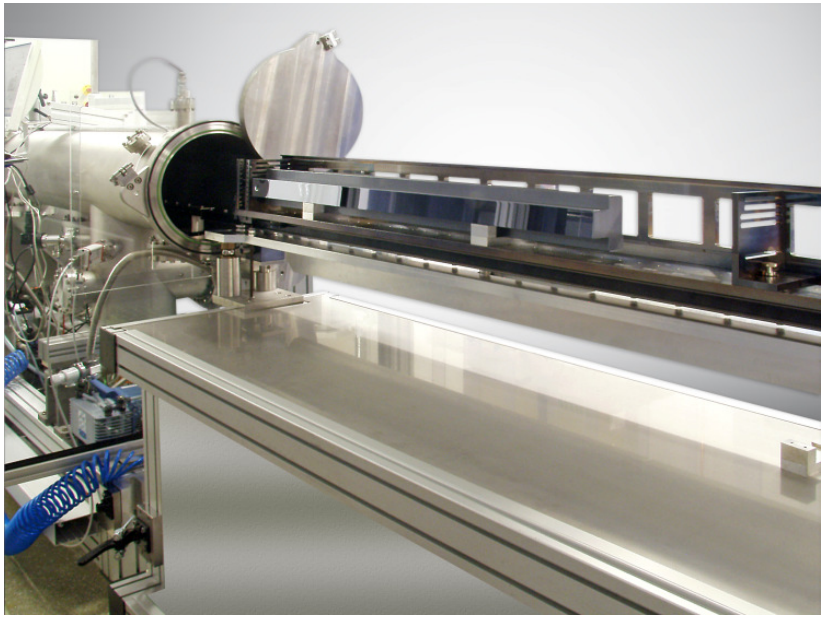


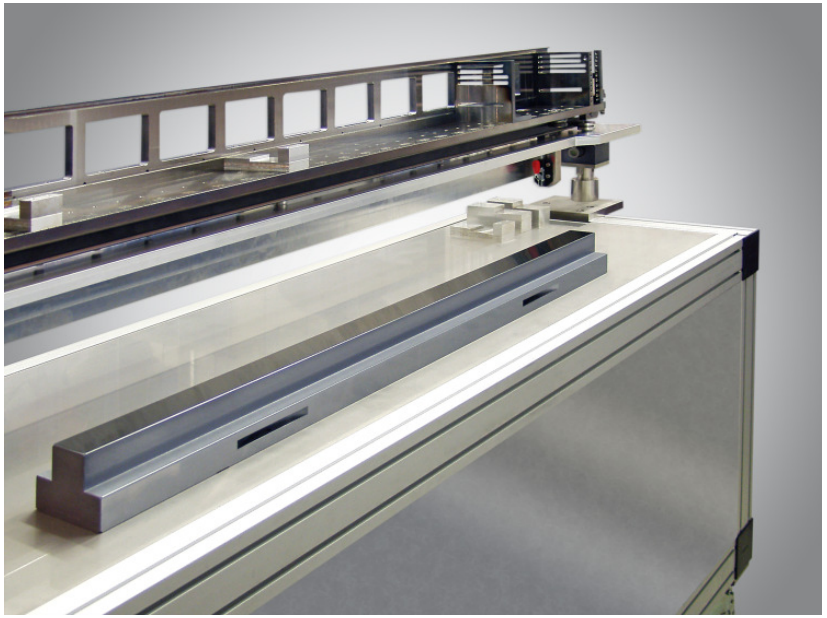
d-spacing accuracy better 0.2% over 500 mm in length!

4. Applications

Total reflection mirror

Special Carbon Coatings: for High Flux Beamlines such as FEL at DESY





100 cm Silicon mirror

Ultra stable special Carbon coatings

4. Applications

Total reflection optics of carbon for FEL

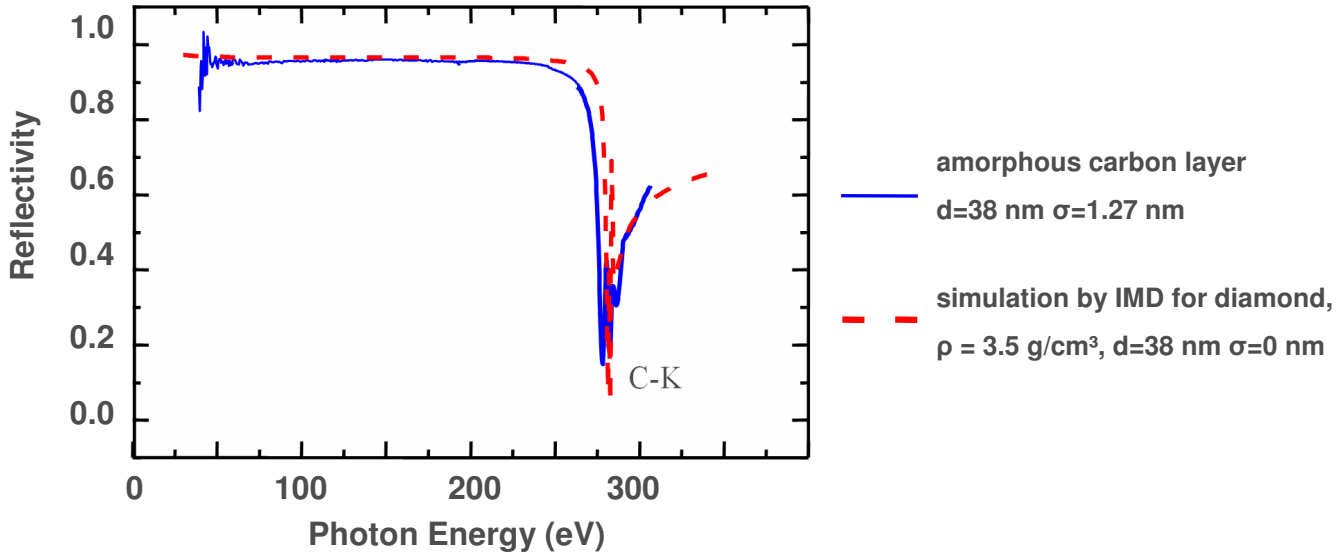
Optics for FEL at Desy

Substrates made by:

Coatings made by:

INCOATEC
innovative coating technologies gmbh

Reflectivity vs. Energy measured at Hasylab



R(E) ~ 95 % at 50 - 240 eV at grazing incidence angle of 2 deg

4. Applications

Multi-stripe X-ray optics as DCMM

Tomography Beamline (M. Stampanoni, PSI-SLS)

PAUL SCHERRER INSTITUT PSI

Substrates made by:

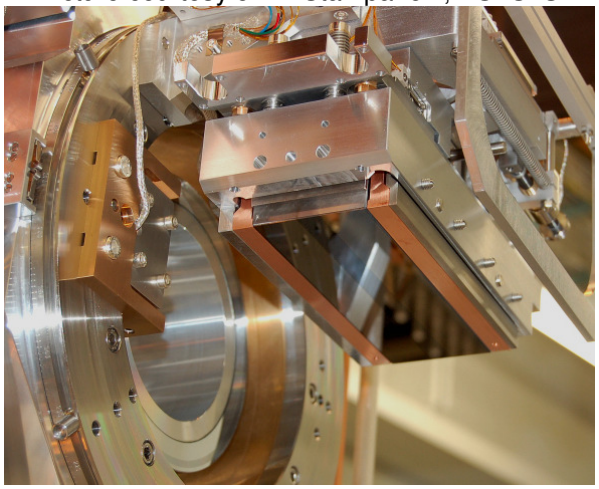
ZEISS

Coatings made by:

INCOATEC innovative coating technologies gmbh

GKSS FORSCHUNGSZENTRUM

Picture courtesy of M. Stampanoni, PSI-SLS



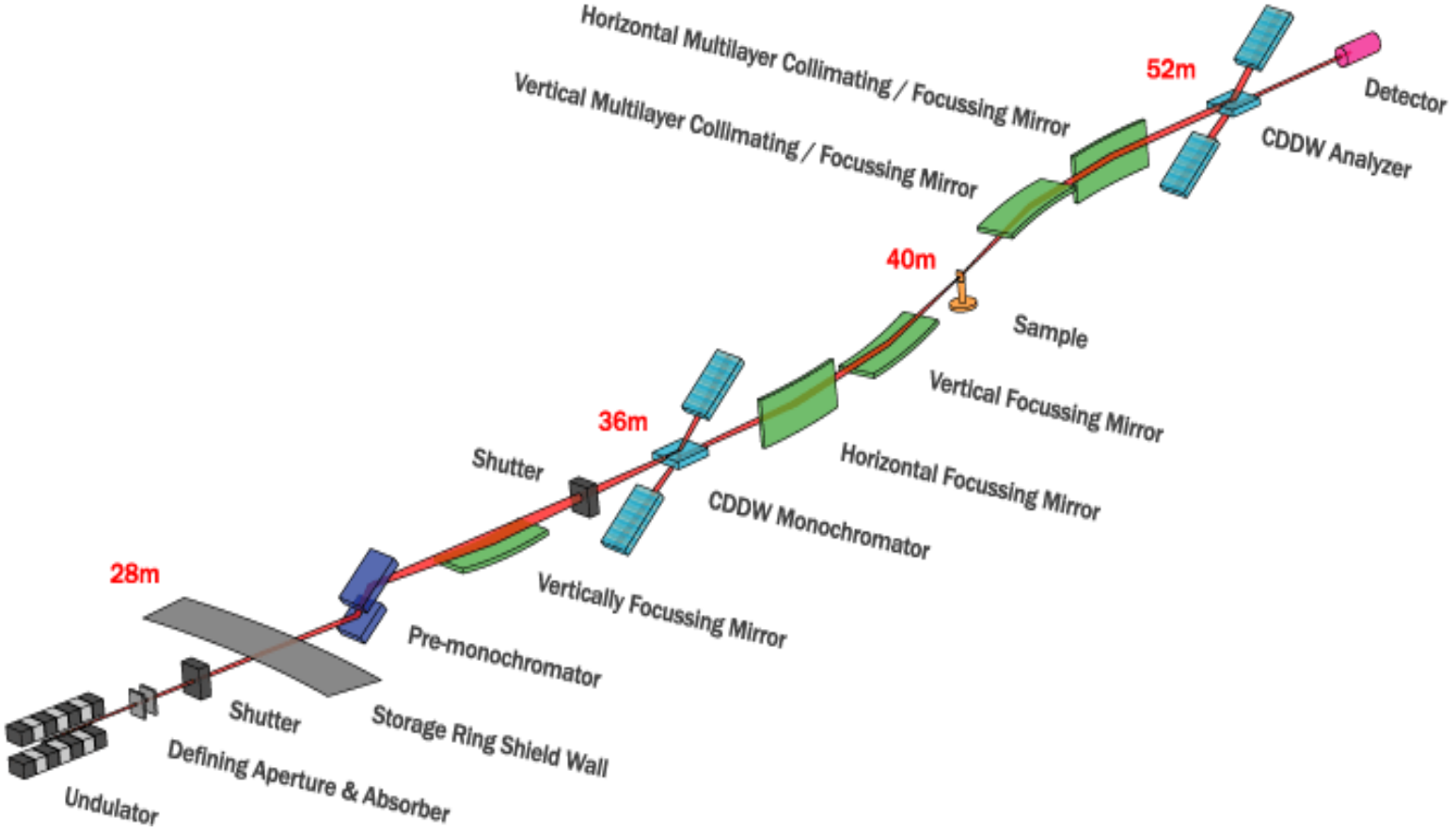
Stripe A : $[Ru/C]_{100}$, d = 4 nm, R > 80% for 10 < E < 22 keV

Midspace: Si111, $\Delta_{orientation}$ < 0.01°, σ = 0.1 nm, slope error 0.04''

Stripe B : $[W/Si]_{100}$, d = 3 nm, R > 80% for 22 < E < 45 keV

4. Applications

Montel Optic for Inelastic X-Ray Scattering

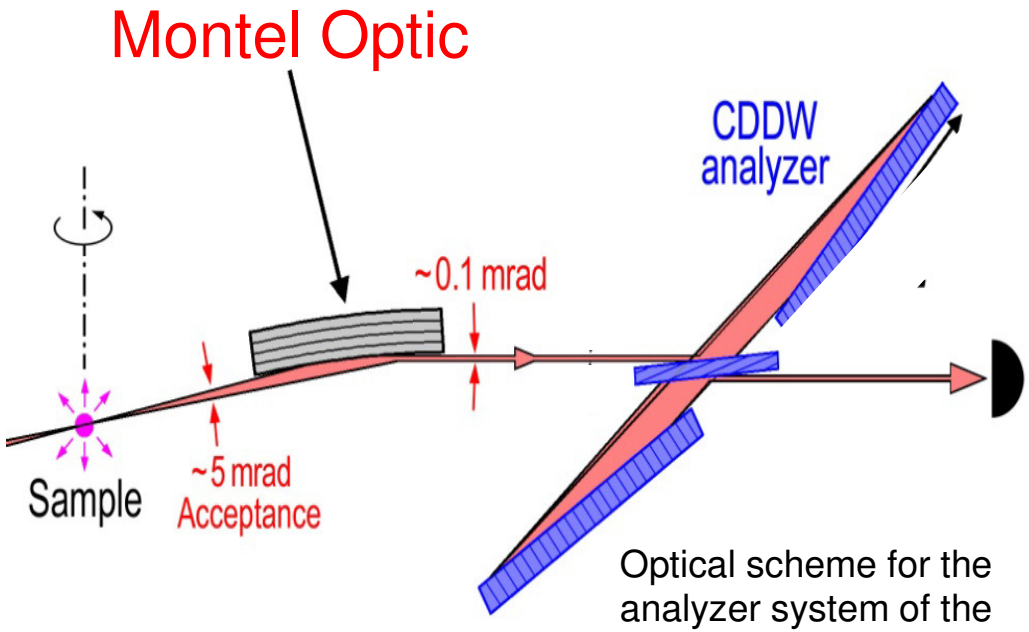


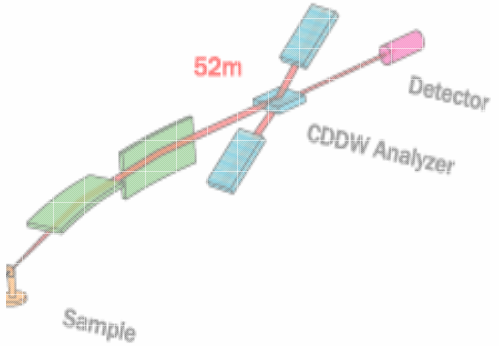
Scheme of INELASTIC X-RAY SCATTERING BEAMLINE at NSLS-II

Reference: IXS@NSLS-II Workshop, February 7-8, 2008, Talk **Yong Cai,** www.bnl.gov/nsls2/workshops/docs/IXS/03_Cai.ppt

4. Applications

Montel Optic for Inelastic X-Ray Scattering





Optical scheme for the analyzer system of the spectrometer

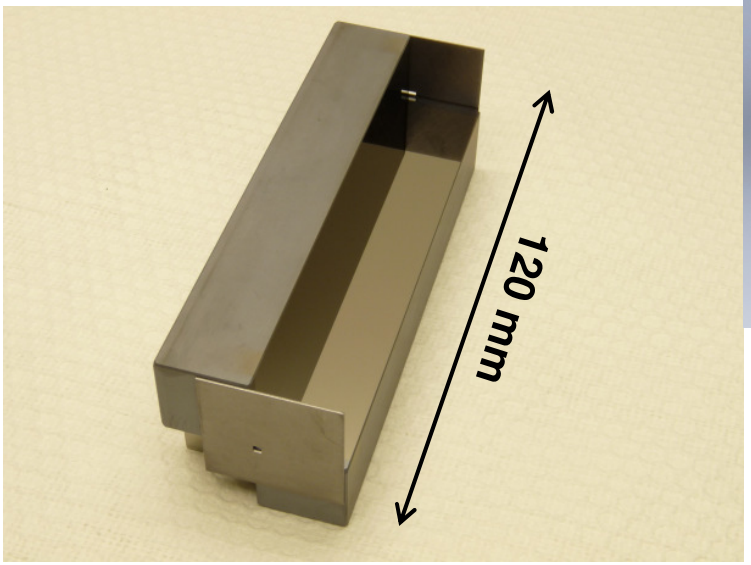
Reference: LT-XFD_CDR_IXS-00123

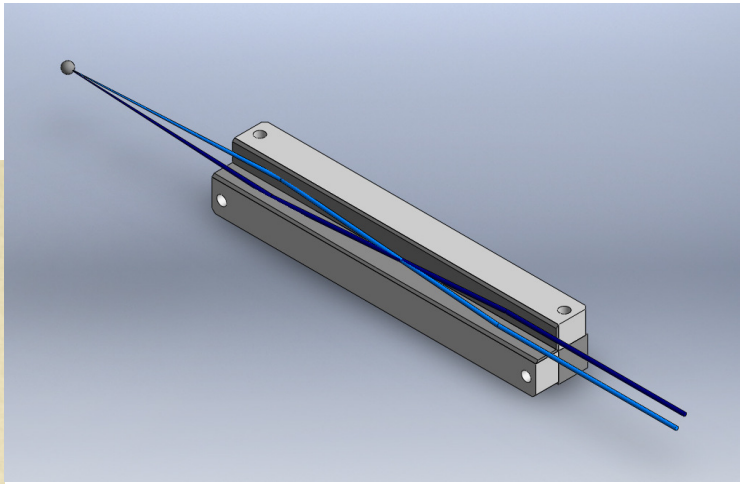
Scheme of INELASTIC X-RAY SCATTERING BEAMLINE at NSLS-II

Reference: IXS@NSLS-II Workshop, February 7-8, 2008, Talk **Yong Cai,** www.bnl.gov/nsls2/workshops/docs/IXS/03_Cai.ppt

4. Applications

2 dimensional Montel Optic for Synchrotrons





First 3rd Generation Montel Optics for Synchrotrons
Designed as an analyzer system for inelastic scattering beamlines.

Conclusion - Our customers

- Zeiss
- JenOptik
- Desy / Hasylab
- Bessy
- Elettra
- CLS
- APS / ANL
- Swiss Light Source
- SESO
- NSLS
- DLS
- Lyncean Tech.

Conclusion - Our profile

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

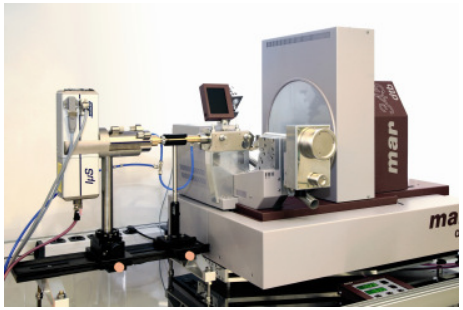
- Physical Vapour Deposition (PVD) methods for coatings
  - Extreme precise coatings
  - Large area coatings
  - With gradients / stripes / monolayer / multilayer

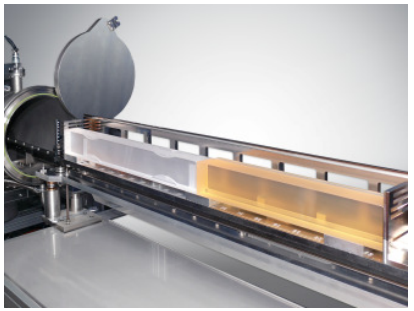
- Characterization of thin films

We produce the optics custom-made!

Flexible “in-house” manufacturing for various wavelengths and applications

Your Partner for X-Ray Optics and Microfocus Sources





Incoatec GmbH
Max-Planck-Str. 2 • 21502 Geesthacht
Germany
Tel: +49 (0) 41 52 - 88 93 81
www.incoatec.de