

Physikalisch-Technische Bundesanstalt Braunschweig und Berlin Nationales Metrologieinstitut

UHV instrumentation and alignment strategies

- XRS instrumention -

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Joint ICTP-IAEA School on

Novel Experimental Methodologies for Synchrotron Radiation Applications in Nano-science and Environmental Monitoring

17 November - 28 November 2014

Outline



- 1 Motivation
- 2 PTB's development of an UHV instrument for XRS/XRR nanoanalytics
- 3 Technology transfer to TU Berlin, CEA/LNHB and IAEA
- 4 IAEA measuring chamber measurement options
- 5 Characterization of the IAEA measuring chamber
- 6 Principles of sample alignment
- 7 Operational recommendations
- 8 PTB control software



- Ever decreasing sizes of components and the ever greater complexity of electronic assemblies require an analyzing method for ever decreasing mass depositions and elemental concentrations as well as ever decreasing layer thicknesses.
- Increasing demands on quality for nanoscaled materials:
 - Fast non-destructive procedure
 - High accuracy X-Ray Spectrometry (XRS)
 - **High reliability**

- Lack of reference materials at the nanoscale



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2. PTB's development of an UHV instrument for XRS/XRR nanoanalytics

X-ray and IR Spectrometry



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Designed by PTB to match various different project requirements with high flexibility and reliability.



3. Technology transfer to TU Berlin, CEA/LNHB and IAEA

TU-Berlin:





- Transfer to TU Berlin and with TU Berlin to IAEA and LNE-LNHB successfully completed
- Differences to PTB instrument:
 - 7-axis manipulator instead of 9-axes
 - without aperture system reference-free measurements with moderate uncertainties possible
 - polarization dependent measurements not possible

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IAEA-instrument at PTB's PGM-beamline:



LNE-LNHB at synchrotron facility SOLEIL:



3. Contact information: European metrology and XRS facilities

European Association of National Metrology Institutes (EURAMET):

www.euramet.org/index.php?id=objectives

PTB Technical Cooperation: Europe, Asia, Latin America, Africa and Middle East

www.ptb.de/cms/en/fachabteilungen/abtq/fb-q5.html

PTB at synchrotron radiation facility BESSY II, Berlin, Germany:

www.ptb.de/cms/en/fachabteilungen/abt7/fb-72/ag-724.html

LNE-LNHB at synchrotron radiation facility SOLEIL, Paris, France:

- www.nucleide.org
- www.synchrotron-soleil.fr/portal/page/portal/Recherche/LignesLumiere/METROLOGIE

Synchrotron radiation facility ELETTRA, Trieste, Italy:

https://www.elettra.trieste.it/lightsources/elettra/elettrabeamlines/microfluorescence/x-ray-fluorescence.html

Berlin Laboratory for Innovative X-ray Technologies, Berlin, Germany

http://www.blix.tu-berlin.de/en/index.html

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e progrès, une passion à partager.



Elettra Sincrotrone Trieste



4. IAEA measuring chamber – measurement options





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4. IAEA measuring chamber – measurement options



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X-ray and IR Spectrometry

- XRS or XRR results should not be affected by any artifacts of the sample movement.
- Each axis of the sample manipulator is very well characterized in experimental environment.





Courtesy of Huber Diffraktionstechnik GmbH & Co. KG



Characterization methodology as in diploma thesis of J. Lubeck, PTB.

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Sample_X axis

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Sample_X axis

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Sample_Yaxis

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Sample_Yaxis

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Results of the linear axes of sample movements

	Pitch / "		Yaw	/"	Roll / "		
Linear axis	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
sample_X	30	28	16	15	12	-	
sample_Y	10	11	31	14	10	-	
sample_Z	30	-	2	-	2	-	

- → Characterization delivers very good results
- \rightarrow During mapping of 20 mm x 20 mm the maximum angle

change is 6" which means 0.6 $\mu n^{\text{-}}$



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Results of the rotational axes

Theta Theta Courtes of Huber Diffskions-

Rotational axis	Repeatability (unidir.) / "	Reversal error / "	Optimal backlash distance / °	
Phi (at 0° while moving from -150° to 150°)	2.5	3.1	0.3	
Theta (at 15° while moving from -105° to 75°)	2.3	4.2	0.1	
2Theta (at 30° while moving from 0° to 150°)	7.0	9.4	0.1	

- → Characterization delivers very good results
- \rightarrow All measurements were performed without using encoders
- \rightarrow 10 repeated runs



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6. Principles of sample alignment



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Procedure for sample aligment

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7. Operational recommendations

Do not move all axes at the same time!

> Attention during measurements involving the SDD

- Do not cut the SDD with the 2Theta arm
- If the SDD is very close to the samples, be very careful with sample movements (Theta, X, Y, Z & Phi)
- ➤ Attention during Phi rotations → do not hit the diode arm with a motor of sample_X or sample_Y





8. PTB control software

X-ray and IR Spectrometry

- Modular structure with GUI
- Main window, windows for detectors, motors, online plot
- Saving data of storage ring, beamline and experiment
- Append, parallel and inner scans with changing detectors/motors
- "Go to" functions during and after scans
- Scan normalized on a reference scan

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Thank you for your attention!



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