REFLECTOMETER
Soft X-Ray (UHV-)Triple Axis Diffractometer

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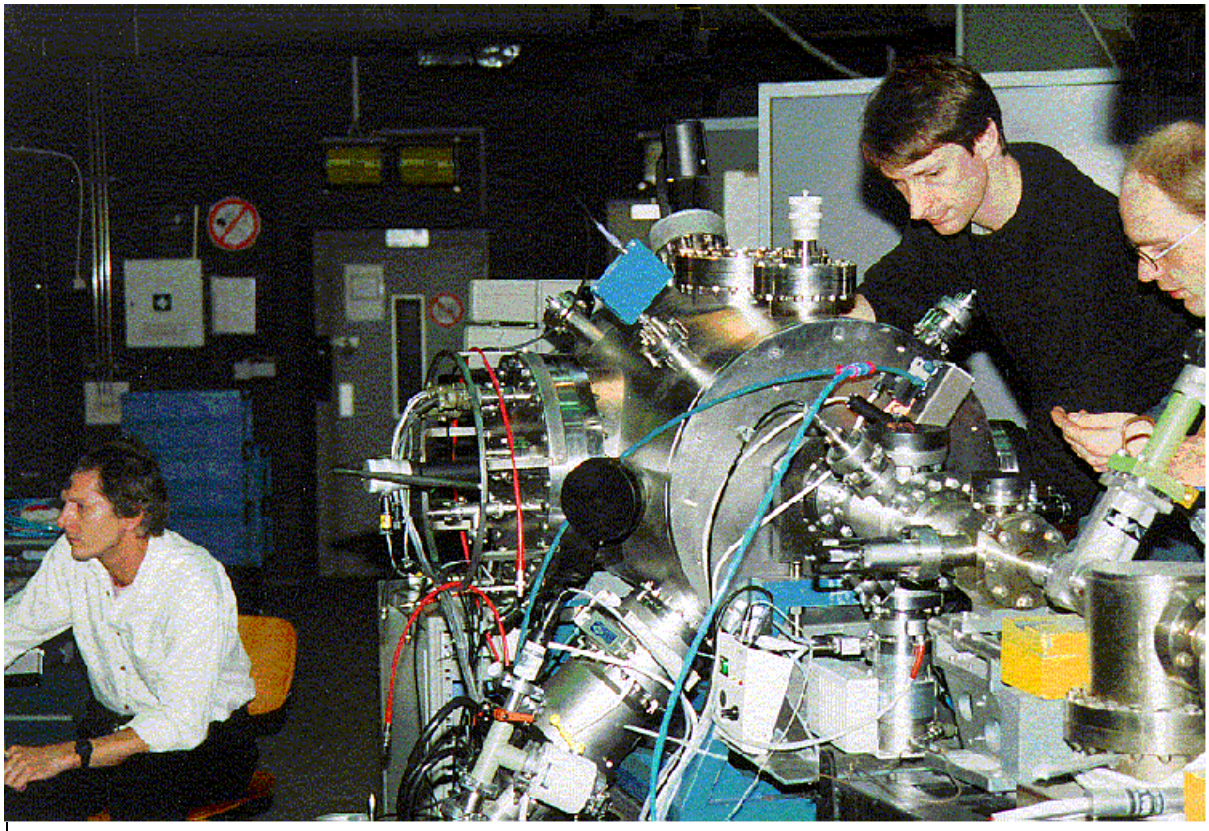

The reflectometer is a multipurpose instrument to determine the optical properties of samples in transmission or reflection. The reflectivity can be determined at a fixed photon energy as function of the incidence angle or vice versa as function of the energy for a certain incidence angle. The samples can have a size from a few square millimeters to macroscopic optical elements, thus performance measurements on realistic beamline optical components like mirrors, gratings or crystals are possible as well as the investigation of e.g. multilayer samples on Si-wafer substrates.

The ultra-high-vacuum chamber is evacuated by a 340 l/s turbomolecular pump. The base pressure is better than 10-7 mbar. Via a diferentially pumped stage the system can be mounted at any UV-, soft or hard x-ray monochromator.
It is equipped with 3 UHV-compatible one-circle goniometers (Huber 408 and 410) and UHV stepper motors (Phytron) for varying the incidence angle at the sample and for positioning the detector in plane or out of plane. The reflection plane is vertical (i.e. in general s-polarisation geometry).

Typical experiments

- **Development and performance tests on optical elements: Mirrors, multilayers, gratings, films, crystals**
- **Measurements of reflectivity, efficiency, transmission, diffraction as function of incidence angle or photon energy**
- **Characterisation of optical surfaces**
- **Scattering (specular - non specular)**
- **Straylight, surface roughness and energy resolution**

References

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5. S. Yulin et al., ***Enhanced reflectivity and stability of Sc/Si multilayers***, SPIE-Proc. **5193,** 155-163 (2003)
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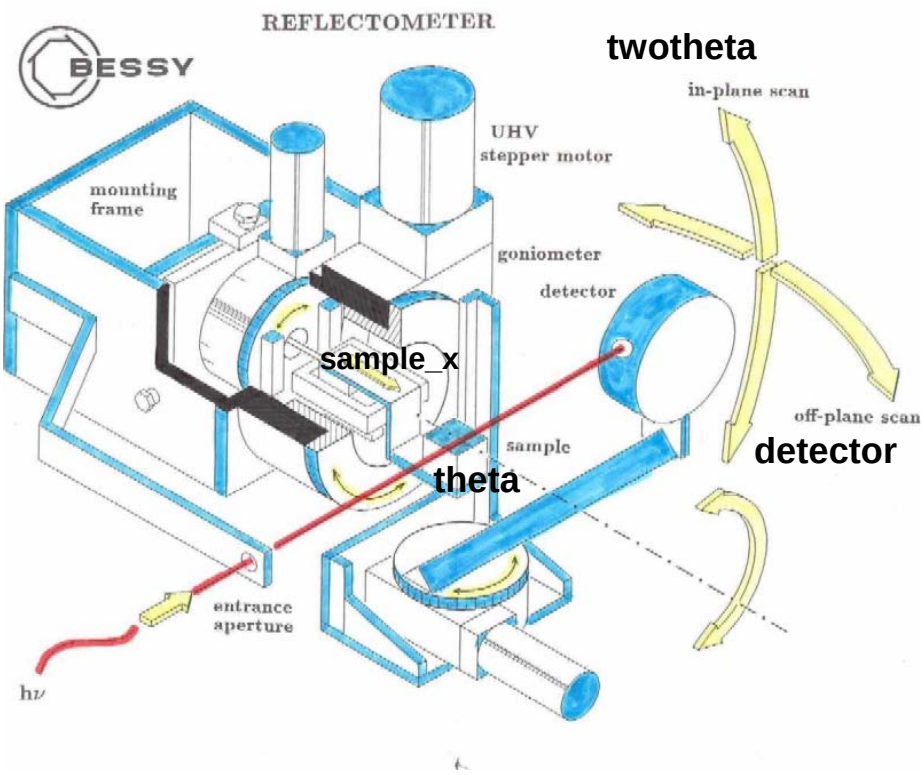
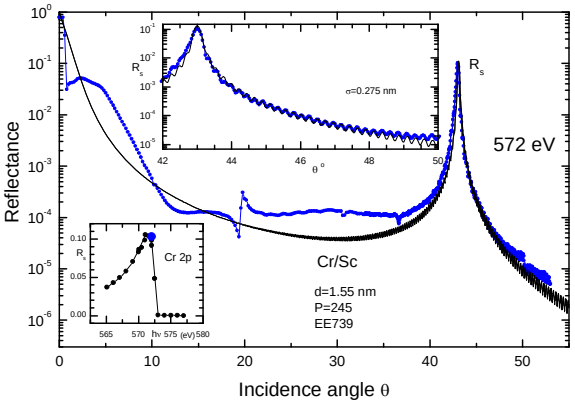
16. E.O. Filatova et al., ***Soft X-Ray Reflectometry, Hard X-Ray Photoelectron Spectroscopy, and HRTEM investigations of the internal structure of TiO_2(Ti)/SiO_2/Si stacks,*** Science & Tech. Adv. Mat. (2011)

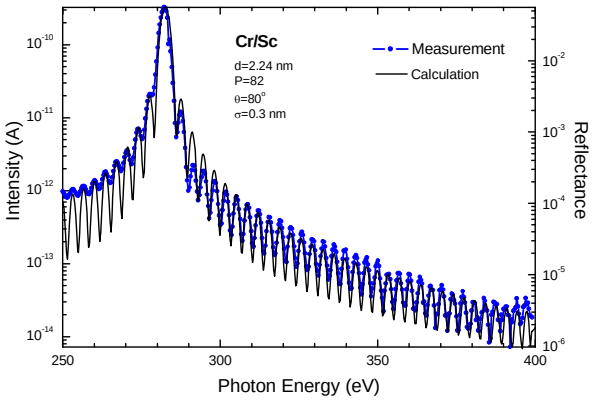
Technical sketch of the UHV-triple axes configuration



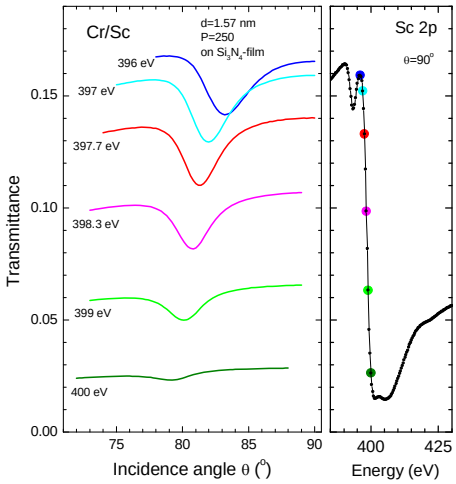
EXAMPLES



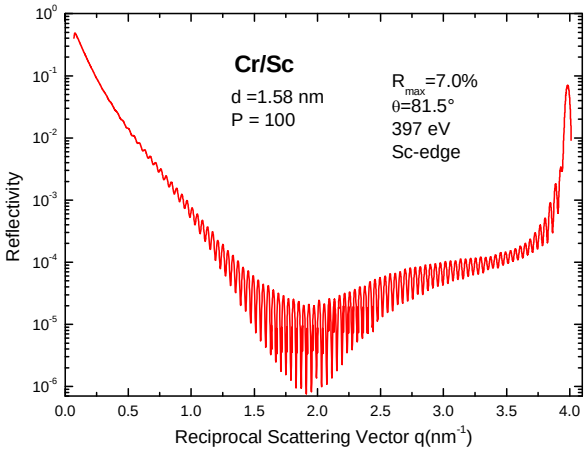
Reflectivity curve of a multilayer mirror - (2:1; θ:2θ angular scan) [5,6]



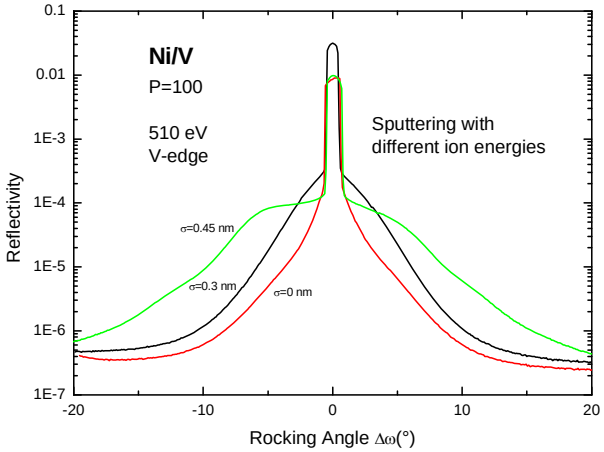
Reflectivity curve of a multilayer mirror - energy scan [2,5]



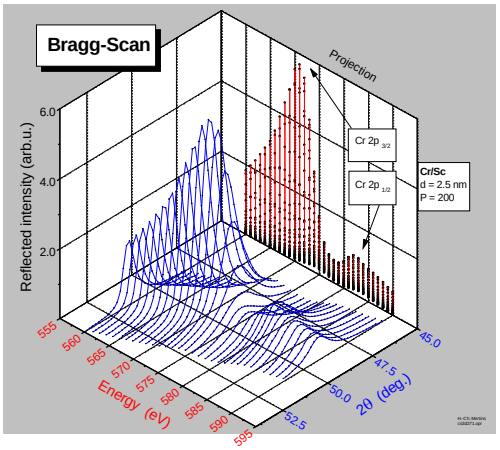
Transmission curves of multilayer films in the vicinity of an absorption edge [2]



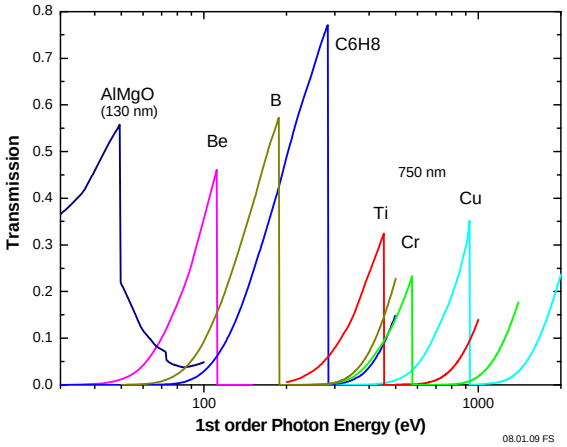
Multilayer reflectivity as function of the reciprocal scattering vector (F. Eriksson, Linköping, Sweden)



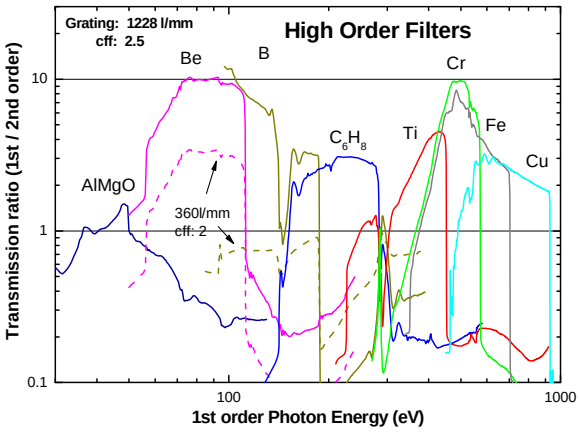
Diffuse (off-specular) scan of multilayers (F. Eriksson, Linköping, Sweden)



Reflectivity across an absorption edge - Bragg scan (hv-θ:2θ) [2]



Transmission of High-Order Filters

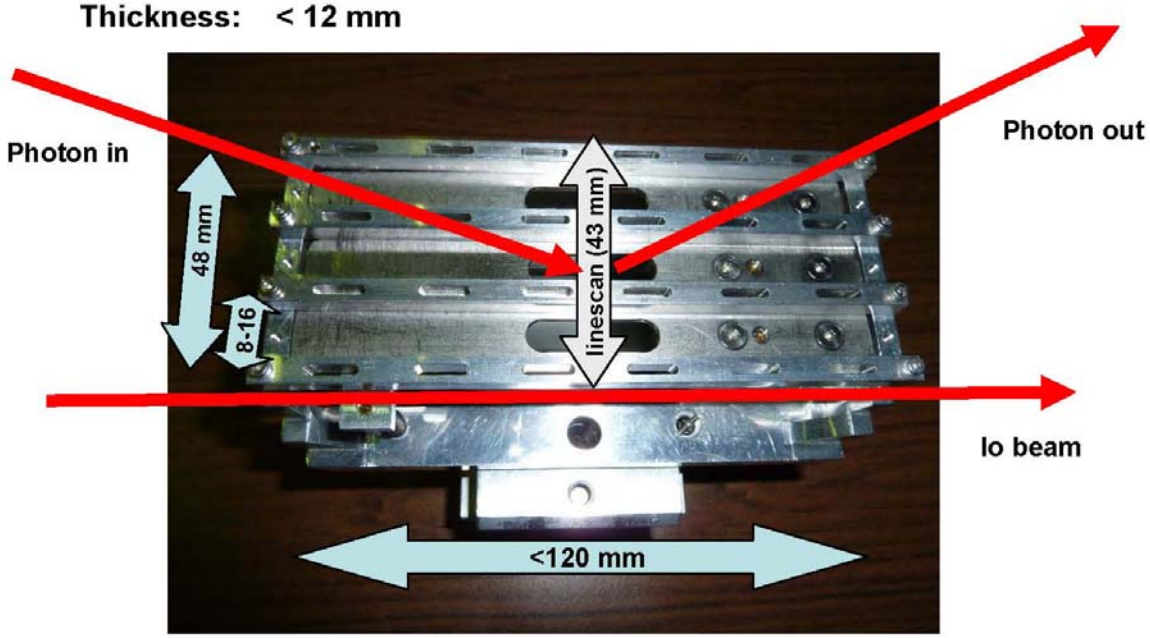


Suppression ratio of High Orders

Sample holder of BESSY Reflectometer for light samples (e.g. wafers)

How many samples	Width (mm)	
6	8	(2 each with same thickness)
3	16	(different thickness poss.)
2	24	
1	48	(or larger (<150 mm))

Max. Length: 120 mm
Thickness: < 12 mm



TECHNICAL DATA	
Io - light diagnostics	
Higher order filters	Al/Mg/Al (29/107/29 nm), B, Be, C_6H_8, Ti, Cr, Fe, (Cu) (750 nm)
Entrance pinholes	0.16, 0.3, 0.6, 1.2, 2.5 mm ϕ
Detectors	Au-mesh, GaAsP diode
Samples	**Multilayers, mirrors, gratings, crystals, thin films**
Maximum dimension	150 x 40 x 35 mm^3
Minimum optical surface size	5 x 5 mm^2
Incidence angle scan range	-90° - +90°
Minimum angle to normal	1^o
Lateral translation	50 mm
Minimum angle to normal incidence	2.5°
Minimum step size	0.001°
Detector	- GaAsP-photodiodes with Keithley electrometer 617 (6514) - Channeltron (pulse counting)
Dark current	30 10^{-15} A
Dynamic range	up to 8 orders of magnitude
Entrance aperture	0.16 – 2.5 mm
Scan range in plane	0 – 360°
off-plane	-15° – 180°
Min. step size in plane	0.0005°
off plane	0.001°
Sample – Detector Distance	150 mm
UHV-chamber	
Vacuum	<1 10^{-7}
Beam height	1400 $\pm$300 mm
Adjustments w.r.t. SR:	x, z, pitch, yaw, roll
Computer control	
Hardware (polaris.exp.bessy.de)	Intel(R) Pentium(R) D CPU 3.40GHz, 1GB RAM, 250 GB
Software	Linux (Debian Etch) / SPEC 5.06
Scan options	hν, θ, 2θ, detector off-plane, θ-2θ
multilayers, crystals:	Bragg-peak-scan (hν-θ-2θ)
gratings:	constant α, -β, -α+β, on-blaze