POLARIMETER
Soft X-Ray (UHV-) 8 Axes Diffractometer

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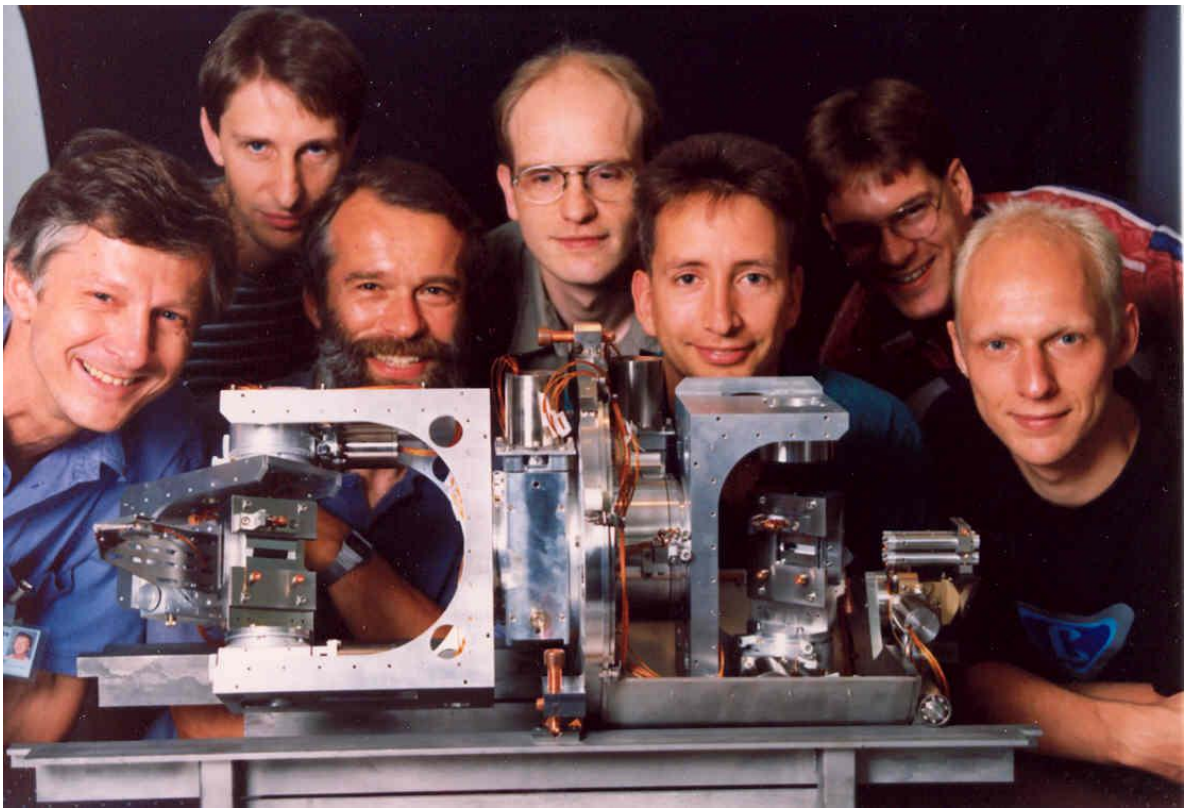


The high precision 8-axes ultra-high vacuum compatible (UHV)-polarimeter is a multipurpose instrument which can be used as a selfcalibrating polarisation detector for linearly and circularly polarised UV- and soft X-ray light [1, 2]. It can also be used for the characterisation of either reflection or transmission properties (reflectometer) or polarising and phase retarding properties (ellipsometer) of any optical element [3].
Magneto-optical experiments are possible in transmission, as the XMCD [4]or XMLD [5] (Magnetic Circular / Linear Dichroism) that are intensity measurements. Additionally a polarisation analysis of the transmitted light is possible which allows for Faraday- [4] or Voigt-measurements [5]. In reflection the magneto-optical Kerr effect can be exploited in longitudinal (L-MOKE) or transversal (T-MOKE) geometry as intensity measurement [6 - 8] to investigate thin films as well as magnetic multilayers [9]. Independent two-dimensional rotation of the detector enables any non-specular magnetic scattering experiment on magnetic dots or grains. A load-lock transfer chamber allows for quick and easy sample exchange.

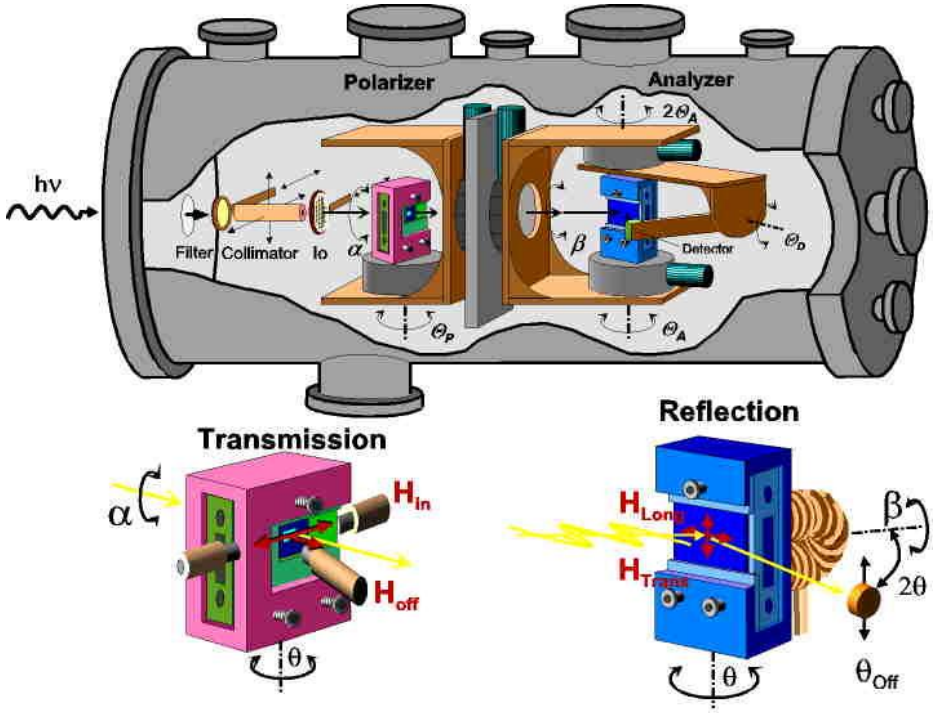
Typical experiments

- **Reflectometry, ellipsometry (multilayer mirrors, films)**
  - **Characterisation of optical elements**
  - **Reflection, transmission properties (s-, p-pol.)**
  - **Polarising properties (phase retardation)**
- **Polarimetry (with two optical elements)**
  - **Determination of polarisation of incident light (Stokes $S_{0,1,2,3}$)**
    Polarisers: transmission multilayers, λ/4-plates
    Linear Analysers: reflection multilayers, mirrors
- **Magneto-optical spectroscopy (in reflection, transmission)**
  - **Resonant Magnetic Scattering (specular and diffuse)**
  - **Intensity spectroscopy: MCD, LMD, Kerr-effect (L, T-MOKE)**
  - **Polarisation spectroscopy: Faraday-, Voigt-effect**

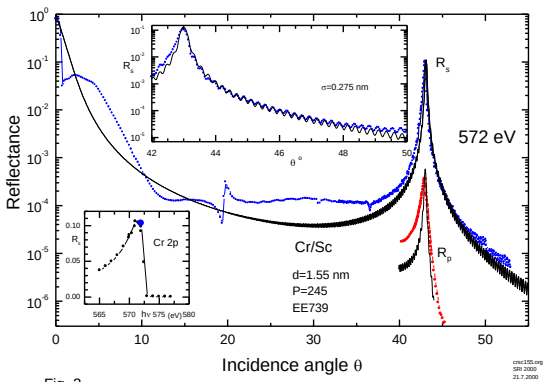
References

[1] F. Schäfers et al., ***A Soft Soft X-Ray Polarimeter using Multilayer Optics: Complete Analysis of the Polarization State of Light,*** Appl. Opt. **38**, 4074-4088 (1999)
[2] F. Schäfers, ***Multilayers for the EUV/Soft X-ray Range,*** Physica B 283, 119-124 (2000)
[3] H.-Ch. Mertins et al., ***Observation of the X-ray Magneto-Optical Voigt Effect,*** Phys. Rev. Lett. **87**, 047401-1–4, (2001)
[4] H.-Ch. Mertins et al., ***Resonant magnetic reflection coefficients at the Fe 2p edge obtained with linearly and circularly polarized soft x rays***, Phys. Rev. B 66, 184404-1-8 (2002)
[5] O. Zaharko et al., ***Exchange coupling in Fe/NiO/Co film studied by soft x-ray resonant magnetic reflectivity***, Phys. Rev. B 66, 134406 (2002)
[6] Z. Wang et al., ***Broadband multilayer polarizers for the extreme ultraviolet,*** J. Appl. Phys. **99** (5) 056108-1-3 (2006)
[7] F. Eriksson et al., ***Interface Enginering of Short-period Ni/V Multilayer X-ray Mirrors,*** Thin Solid Films **500**, 1-2, 84-95 (2006)
[8] F. Schäfers, ***Multilayer-based Soft X-ray Polarimetry,*** Optics and Precision Engineering (2007)

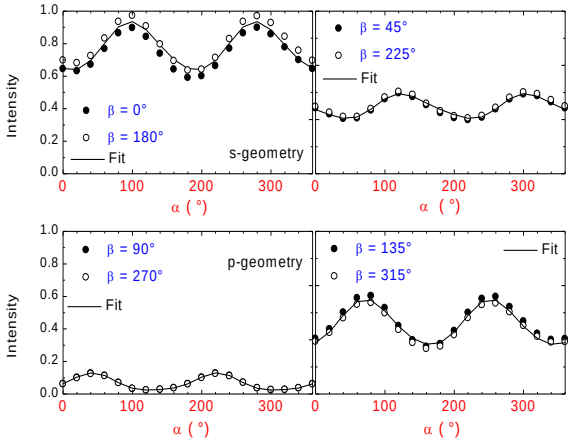
Technical sketch of the UHV 8-axes configuration



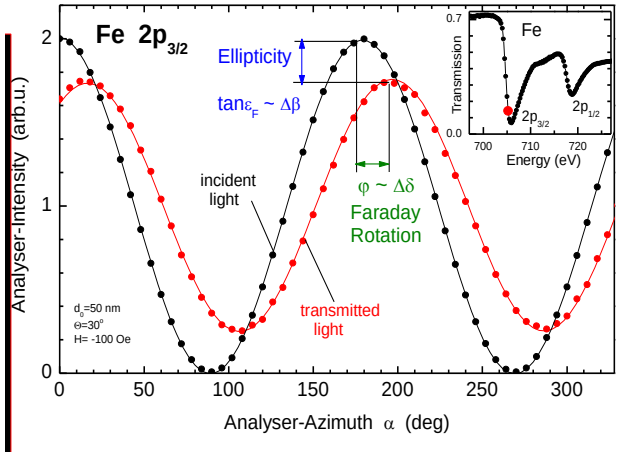
EXAMPLES



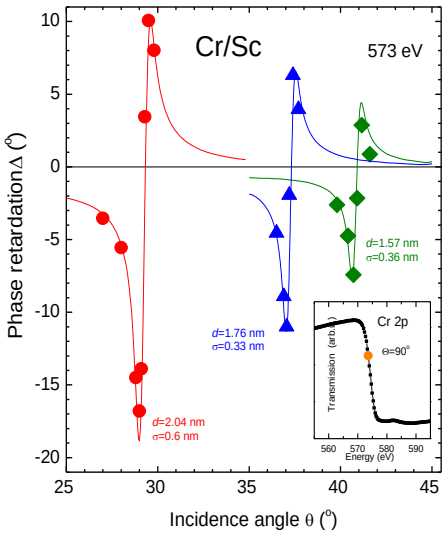
Reflectivity curve of a multilayer mirror - in s- and p-polarisation geometry ((2:1; θ:2θ angular scan) [3]



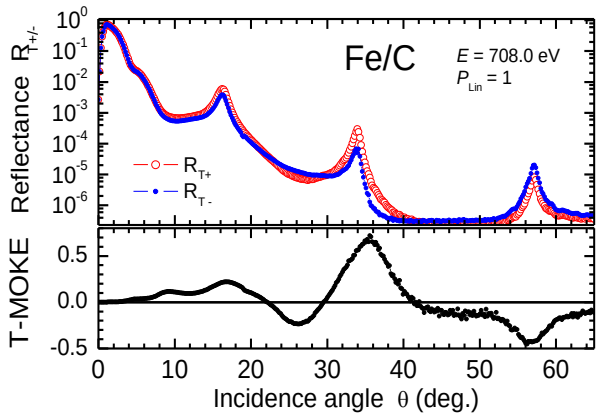
Determination of the complete polarisation state (Stokes vector) of incident light [1]



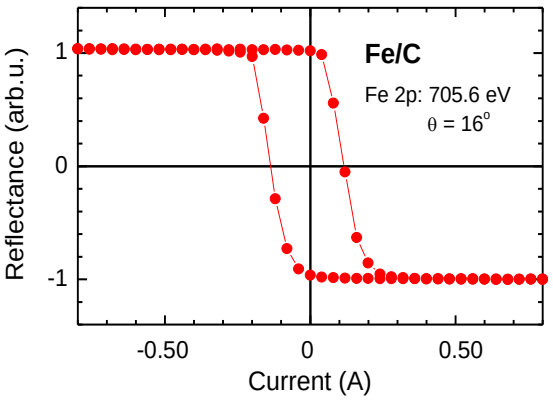
Faraday measurement on a thin Fe-film [4]



Phase retardation of a transmission multilayer [1]



T-MOKE, Reflectance $R_{T+/-}$ and corresponding asymmetry [6]



Hysteresis-curve in reflection

TECHNICAL DATA	
Io - light diagnostics	
Higher order filters	Be, B, C_6H_8, Ti, Cr, Fe
Collimator pinholes	∅ 0.2 – 2.0 mm
Detectors	Au-mesh, Fluorescence screen, GaAsP photodiode
Samples in transmission or reflection	**polarisers, analysers**
Maximum dimension	50 x 50 x 11 mm^3
Minimum dimension	10 x 10 x 0.5 mm^3
Incidence angle scan range	$0^o \leq \Theta_P, \Theta_A \leq 90^o$
Azimuthal angle scan range	$0^o \leq \alpha, \beta \leq 370^o$
Minimum angle to normal incidence	4.5°
Minimum step size	0.001°

Heating	200^{o} C
Magazine store	in-situ change of 10 samples
Load-lock transfer chamber	for 5 samples
Magnetic fields	$-450 \leq H \leq 450$ Oe
Trans.: in-/off-plane	
Refl: long./transv.	
Detector	GaAsP-photodiode with Keithley electrometer 617 (6514)
Dark current	$30 \bullet 10^{-15}$ A
Dynamic range	up to 8 orders of magnitude
Detector size	4x4 mm^2; 0.2x4 mm^2
Scan range in plane	$0^{o} \leq 2\Theta_A \leq 180^{o}$
off-plane	$-10^{o}\ \Theta_D \leq +27^{o}$
Min. step size in plane	0.001°
off plane	0.001°
Sample – Detector Distance	150 mm
UHV-chamber	
Vacuum	$1\ 10^{-8}$
Beam height	1400 $\pm$300 mm
Adjustments w.r.t. SR:	x, y, pitch, yaw, roll
Computer control	
Hardware (speckle.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 azimuth α, β,polar-α, -β
multilayers, crystals:	Bragg-peak-scan (hν-θ-2θ)
gratings:	constant inc./diff./dev. angle