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 self-calibrating 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 S0,1,2,3)
    - 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**


**Technical sketch of the UHV 8-axes configuration**
Reflectivity curve of a multilayer mirror - in s- and p-polarisation geometry ((2:1; 0:2θ 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**

<table>
<thead>
<tr>
<th>Higher order filters</th>
<th>Be, B, C₆H₆, Ti, Cr, Fe</th>
</tr>
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<tbody>
<tr>
<td>Collimator pinholes</td>
<td>ø 0.2 – 2.0 mm</td>
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<tr>
<td>Detectors</td>
<td>Au-mesh, Fluorescence screen, GaAsP photodiode</td>
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</table>

**Samples in transmission or reflection**

| Maximum dimension   | 50 x 50 x 11 mm³      |
| Minimum dimension   | 10 x 10 x 0.5 mm³     |
| Incidence angle scan range | $0° \leq \Theta_p, \Theta_A \leq 90°$ |
| Azimuthal angle scan range | $0° \leq \alpha, \beta \leq 370°$ |
| Minimum angle to normal incidence | 4.5° |
| Minimum step size   | 0.001°                |
### Polarimeter

- **Heating**: 200°C
- **Magazine store**: in-situ change of 10 samples
- **Load-lock transfer chamber**: for 5 samples
- **Magnetic fields**:
  - Trans.: in-/off-plane
  - Refl.: long./transv.
  - \(-450 \leq H \leq 450 \text{ Oe}\)

### Detector

- **GaAsP-photodiode with Keithley electrometer 617 (6514)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Dark current</td>
<td>$3 \times 10^{-13} \text{ A}$</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>up to 8 orders of magnitude</td>
</tr>
<tr>
<td>Detector size</td>
<td>$4 \times 4 \text{ mm}^2; 0.2 \times 4 \text{ mm}^2$</td>
</tr>
<tr>
<td>Scan range in plane</td>
<td>$0^\circ \leq 2\Theta_A \leq 180^\circ$</td>
</tr>
<tr>
<td>Off-plane</td>
<td>$-10^\circ \leq \Theta_D \leq +27^\circ$</td>
</tr>
<tr>
<td>Min. step size in plane</td>
<td>$0.001^\circ$</td>
</tr>
<tr>
<td>Off plane</td>
<td>$0.001^\circ$</td>
</tr>
<tr>
<td>Sample – Detector Distance</td>
<td>150 mm</td>
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### UHV-chamber

- **Vacuum**: $1 \times 10^{-8}$
- **Beam height**: $1400 \pm 300 \text{ mm}$
- **Adjustments w.r.t. SR**: x, y, pitch, yaw, roll

### Computer control

- **Hardware**: (speckle.exp.bessy.de)
- **Software**: Intel(R) Pentium(R) D CPU
  - 3.40GHz, 1GB RAM, 250 GB
  - Linux (Debian Etch) / SPEC 5.06
- **Scan options**: hv, \(\theta\), 20, detector off-plane, 0-20
  - Azimuth \(\alpha\), \(\beta\)
  - Polar-\(\alpha\), -\(\beta\)
  - Bragg-peak-scan (hv-0-20)
  - Constant inc./diff./dev. angle