ESRF

Experiment title:

X-RAY CIRCULAR DIFFERENTIAL REFLECTOMETRY OF GYROTROPIC CRYSTALS AND CHIRAL SURFACES

Experiment number: HE-747

Beamline: ID12-A

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X-ray *Magnetic* Circular Differential Reflectivity (XMCDR) spectra have already been successfully recorded at beamline ID12A in 1997 using two magnetically polarized mirrors (project HE126)[1]. As in this previous experiment, a double bounce reflectometer was inserted ***upstream*** with respect to the double crystal monochromator: whereas the first mirror (accepting the full heat load from the source) was a polished silicon wafer coated with a thin overlayer of Co, the second mirror was replaced by a cryogenically cooled single crystal of paratellurite (TeO_2) which is gyrotropic. The mirror length could be kept short (40 mm) because we used a narrow undulator beam: 300 µm (V) x 100 µm (H) *deflected in the horizontal plane*. Since we discovered that the instrument used in 1997 had hidden mechanical problems jeopardizing the reproducibility of the experiments, we built a *new* reflectometer (Fig. 1) which is fully UHV compatible, easy to operate and much more reliable. As already emphasized elsewhere, this configuration benefits of the double advantage that the spectra are (i) insensitive to the polarization transfer of the monochromator; (ii) surface sensitive if the angle of incidence is kept well below the critical value ($\theta_c \approx 9$ mrad for TeO_2). We found it mandatory, however, to generate *artificially* an internal I_0 signal using

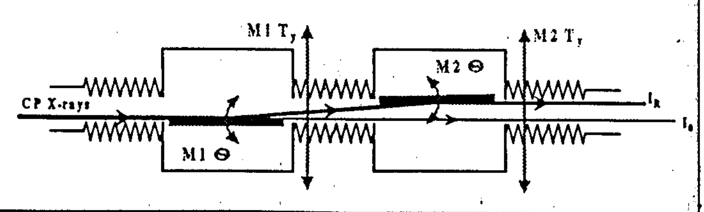
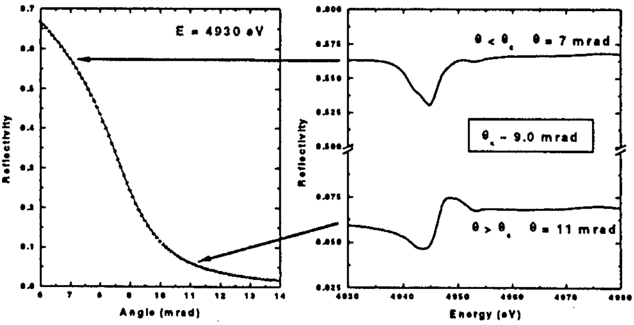


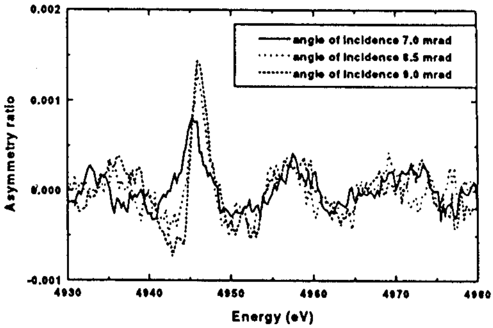
Figure 1:
Schematic top view of the new reflectometer.
- The X-ray beam is deflected in the horizontal plane.
- Some fraction of unreflected incident beam is exploited for monitoring Io.

a fraction of unreflected beam (see Fig.1) catched by an independent Si photodiode located *after* the monochromator. The source noise was less dramatic in our previous XMCDR experiments performed with magnetic mirrors because the magnetization could be flipped several times for each energy data point and the asymmetry factor $[I^-/I^+-1]$ was more or less self-normalized. A similar procedure completely failed for the present XNCDR experiments (even with the new EMPHU source) due to excessive beam instabilities but the use of the internal I_0 improved quite substantially the quality of the spectra.



Figures 2 :
(2a) Angular dependence of the reflectivity profile of TeO_2 slightly below the edge.
(2b) Reflectivity spectra when the energy is scanned accross the L_I Te edge.

Figure 3:
X-Ray *Natural* Circular Differential Reflectivity (XNCDR) spectra recorded at 3 different angles of incidence. The TeO2 crystal was cut with its optical axis parallel to the surface.



As illustrated by Fig. 2a/2b, the quality of the reflectivity spectra recorded near the Te L_I-edge is quite satisfactory although the inherent absorption of the L_{II-III} edges is fairly high. We have reproduced in Fig. 3 selected X-ray *Natural* Circular Differential Reflectivity (XNCDR) spectra recorded at 3 typical angles of incidence, the optical axis of the TeO_2 crystal being parallel to the surface. As predicted by theory, we found that near θ_c (*i.e.* at 9 mrad), the XNCDR spectrum clearly becomes dominated by the *dispersive* part of the gyrotropy tensor, whereas at very grazing angles ($\theta \leq 7$ mrad), it is dominated by the *absorptive* part and is very similar to the bulk XNCD spectrum. Indeed, the two line shapes are related one to each other by the Kramers-Kronig Transform. This experiment proves that the gyrotropy properties of surfaces can be measured by this technique at the ESRF. Unfortunately, the hard disk of the HP workstation controlling the beamline crashed and 80% of our data were definitively lost. This catastrophic failure prevented us from exploiting the spectra recorded with another crystal cut with the optical axis normal to the surface.

References:

[1] C. Neumann, A. Rogalev, J. Goulon, M. Lingham and E. Ziegler, *J. Synchrotron Rad.* (1998), **5**, 998-1000

[2] A. Rogalev, J. Goulon, C. Goulon-Ginet ,G. Benayoun and C. Neumann, (2001), *Nucl. Instrum. & Methods*, Proc. of the SRI-2000 Conference (Berlin)