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ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

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All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Determination of the intensity minima for superstructure reflections of lead chalcogenides by anomalous x-ray scattering	**Experiment number**: HS-1548
Beamline: ID01	**Date of experiment**: from: 07.02.2002 to: 10.02.2002	**Date of report**: 28.02.2002
Shifts: 12	**Local contact(s)**: Tobias Schülli	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

In order to study and characterize highly perfect semiconductor multilayers and quantum dots, we have developed a method which allows discrimination of the different materials in the diffraction pattern from a superlattice. We used anomalous effects at the lead M-edge, in order to suppress the diffraction from PbTe. The atomic scattering factor of lead was determined via fluorescence. In order to interpolate f ’’ correctly in the vicinity of the lead M_V-edge at 2.5 keV, the fluorescence yield was fitted to the theoretical data taken from tables [2]. f ‘ was then calculated according to the Kramers-Kronig relation.

With these values and the momentum corrected f_0 values [2], the intensity minimum was calculated and later measured at PbTe and $Pb_{0.92}Eu_{0.08}Te$ films.

Figure 1a shows the result for the fluorescence (f ’’) and the calculated f ’ for Pb and the tabulated values for Te. At the (111) superstructure reflection of the PbTe-lattice one expects a minimum in the scattered intensity at the intersection point of f_{Pb} and f_{Te}.

The calculated minima for PbTe and $Pb_{0.92}Eu_{0.08}Te$ are plotted in figure 1 b. The measurement on $Pb_{0.92}Eu_{0.08}Te$ was performed as it is used as matrix material for highly ordered self organized quantum dots in multilayers [3].

In the diffraction pattern from a flat multilayer without quantum dots, one can see the sensitivity of this method: A sample of 10 x (6 Monolayers EuTe on 15 Monolayers PbTe) on a 2 micron PbTe-buffer and a BaF_2-substrate was investigated. Figure 2 shows the diffraction pattern on the (111) reflection, together with a simulation for pseudomorphically grown lattice. In this case the EuTe in-plane lattice parameter is forced to the PbTe lattice parameter and relaxes out of plane according to the poisson ratio. The simulation represents a common in-plane parameter of the whole multilayer of $0.88*a_{PbTe}+0.12*a_{EuTe}$. This leads to an out of plane lattice parameter of about $1.028*a_{EuTe}$ for EuTe and $0.996*a_{PbTe}$ for PbTe.

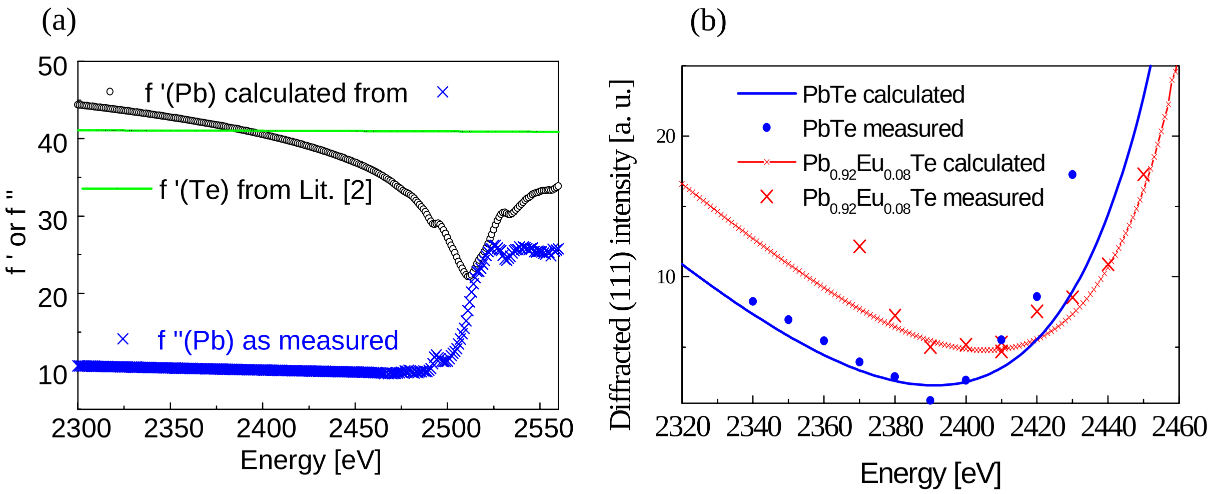

Figure 1 (a): imaginary part of the atomic scattering factor of Pb and the real part calculated via the Kramers-Kronig relation (momentum corrected for the PbTe-(111) reflection). f'(Te) was taken from the tables. For the intersection point at 2390 eV one expects a minimum for the diffracted (111) intensity of PbTe. (b): Calculated and measured (111) intensities for PbTe and $Pb_{0.92}Eu_{0.08}Te$.

Due to the strong suppression of PbTe which scatters at this energy about a factor of 100 weaker than EuTe, the envelope of the superlattice is mainly determined by the lattice parameter and the thickness of the EuTe layers of about 20 Å.

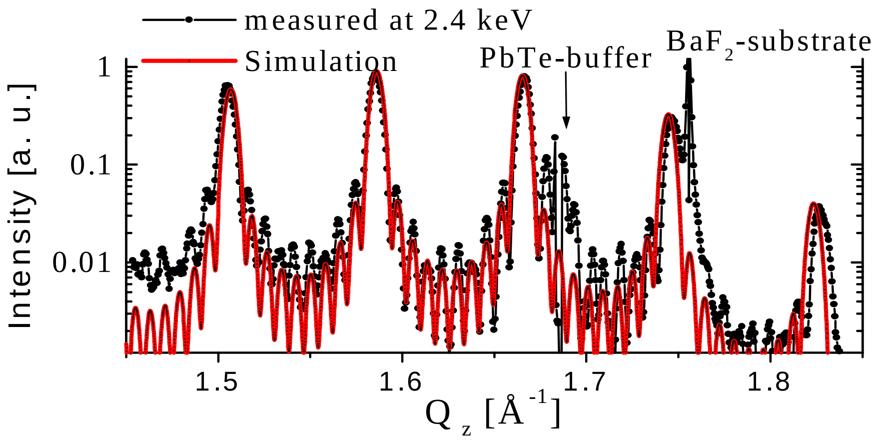

Figure 2: Specular scan on the (111) reflection of a EuTe/PbTe mulilayer (black symbols). The supression of the PbTe scattering allows a determination of the EuTe lattice parameter. The simulation (red line) refers to a pseudomorphically strained EuTe, with an out of plane distortion of + 3%.

In addition, we proposed anomalous diffraction on highly ordered quantum dot superlattices, in order to model and determine the strain distribution in these dots [3], [4]. The damaged mirrors on Id01 did not allow a reliable use of the beamline at low energies due to the heatload on the crystals and the higher harmonics which could not be sufficiently suppressed without mirrors.

References

[1] B. L. Henke, E. M. Gullikson, J. C. Davis, Atomic Data and Nuclear Data Tables **54**, 181 (1993).
[2] J. Baró, M Roteta, J. M. Fernández-Varea, F. Salvat, Radiat. Phys. Chem. **44**, 531 (1994).
[3] G. Springholz, J. Stangl, M. Pinczolits, V. Holy, P. Mikulik, P. Mayer, K. Wiesauer, G. Bauer, D. Smilgies, H.H. Kang, L. Salamaca-Riba, Physica E **7**, 870 (2000).
[4] G. Springholz, V. Holy, M. Pinczolits, G. Bauer, Science **282**, 734 (1998).