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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

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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.

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Experiment title: Anomalous X-ray diffraction from EuSe/PbSe multilayers and PbSe/PbTe quantum dot superlattices	**Experiment number**: Si-760

Beamline: ID01	**Date of experiment**: from: 24.04.2002 to: 30.04.2002	**Date of report**: 28.08.2002
Shifts: 18	**Local contact(s)**: Tobias Schülli	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

Semiconductor multilayers and quantum dots where investigated using anomalous diffraction at the Pb M_V-edge. This allowed a selective suppression of the diffraction from PbTe or PbSe respectively. In PbSe/EuSe multilayers, this allowed the selective study of the strain in the EuSe layers. As the Europium Chalcogenides show a variation of magnetic phases which change under high pressure from antiferro- over ferri- to ferromagnetism [1], a tuning of the latticeparameter via epitaxial strain will allow a control of this magnetic behaviour. As anomalous high resolution x-ray diffraction is the only tool that allows a precise determination of the lattice parameters, it is of crucial importance in the preparation of further magnetic measurements as SQUID or neutron diffraction.

As the investigated compounds crystallize in the rocksalt structure, the (111) structure amplitude reads $F_{(111)}= f_{Pb}-f_{Se}$ for e.g. PbSe. This allows a strong suppression of the PbSe scattering, when f_{Pb} approaches f_{Se}. The latter condition can only be fulfilled at x-ray energies below the Pb M_V-edge around 2.4 keV. In figure 1(a), the atomic scattering factors of Eu, Pb, Se and Te are plotted as a funtion of energy in the vicinity of the Pb M_V-edge. The intersection points between f_{Pb} and f_{Te} at about 2.4 keV and between f_{Pb} and f_{Se} at 2.5 keV allow a suppression of the (111)-reflection for the corresponding compound. In the same manner, a minimum for the scattered intensity can be found for every composition $PbSe_xTe_{(1-x)}$. Figure 1(b) shows a scan over the specular (111)-reflection of a 100x{450 Å PbSeTe/50 Å EuSe}-superlattice (black crosses). In addition to the pronounced EuSe contribution, the long x-ray wavelength allows a high resolution as represented by the excellent visibility of the sattelite oscillations that modulate the Bragg reflection. The red line represents a fitted model.

In highly ordered PbSe/PbTe quantum dot superlattices, this method was exploited to determine the strain in the PbSe dots. In former diffraction experiments, the scattering from these samples was mainly determined by the surrounding PbTe matrix, where the strain modulation caused by the dots leads to the same sattelite reflections determined by the lateral and vertical periodicity of the PbSe-dots. Figure 2 shows a comparison between two reciprocal space maps, recorded at 10 keV and at 2.4 keV. The envelope of the sattelites is clearly shifted for the lower energy, thus allowing for the first time to determine the degree of elastic relaxation inside the PbSe dots. The latter information is crucial for a better understaning of the strain driven ordering [2][3]. To enable the acquisition of reciprocal space maps in the 2.5 keV regime, a new vacuum compatible gas detection system for x-ray energies down to 2 keV was developped on the beamline ID01.

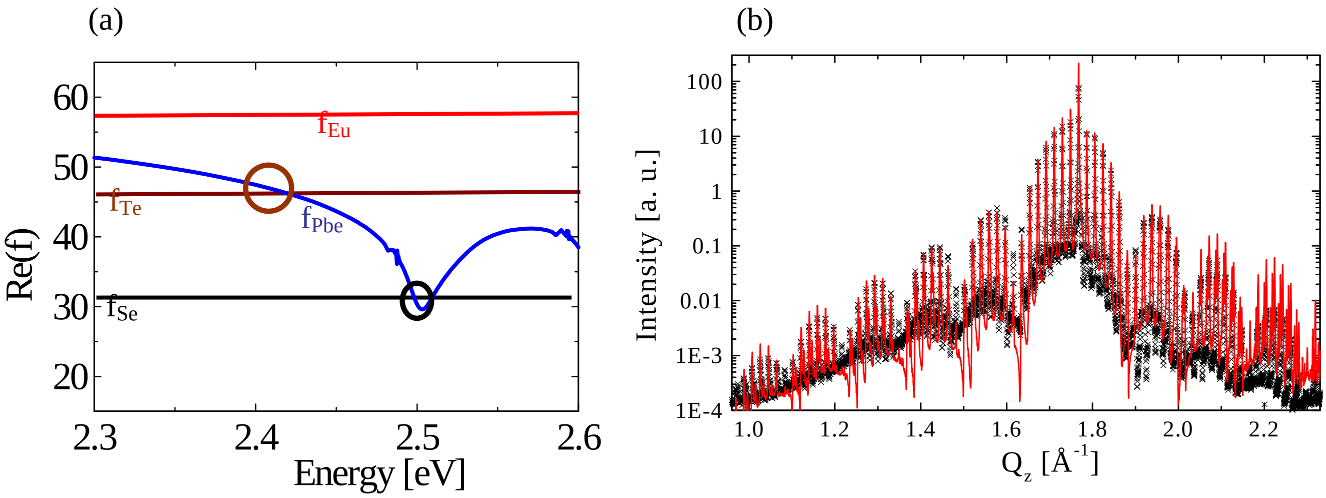

Figure 1 (a): real part of the atomic scattering factor of Eu, Pb, Se and Te.The intersection points at at 2.4 keV and 2.5 keV mark the position where the (111) reflection of PbTe or PbSe have minimum intensity
(b): Scan over the specular (111)-reflection of a 100x{450 Å PbSeTe/50 Å EuSe}-superlattice (black crosses), together with a fitted model (red line).

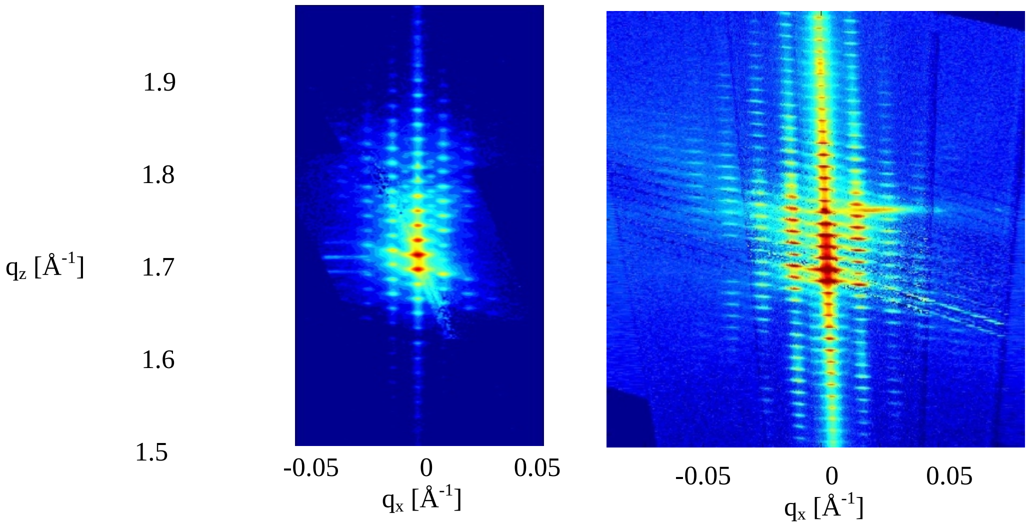

Figure 2: Reciprocal space map around the (111) Bragg reflection of a superlattice of 3D ordered PbSe quantum dots in a PbTe matrix. The left image was recorded at 10 keV, the right one at 2.4 keV, where the scattering is dominated by the quantum dots, as PbTe is suppressed.

References

[1] I.N. Goncharenko and I. Mirebeau, Phys. Rev. Lett. **80**, 1082 (1998).

[2] 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).

[3] G. Springholz, V. Holy, M. Pinczolits, G. Bauer, Science **282**, 734 (1998).