| ESRF | Experiment title: **STANDING WAVES INVESTIGATION OF InAsP/InP SUPERLATTICES** | **Experiment number:** SI 143 |
|---|---|---|
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**Report:**

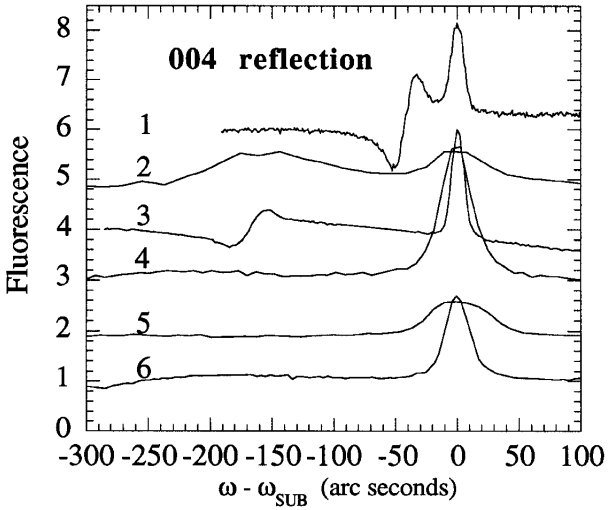
We report on an attempt to extend the X-ray Standing Waves (XSW) technique to semiconductor superlattices (SL), the objective being to assess the ability of XSW to obtain structural information in these systems, and in particular on thin interface layers. The conceptual difficulty lies in the fact that the SL is composed of layers having (at least) two different lattice parameters. Hence it is expected that the XSW field is due to the average diffracting planes. Standard dynamical theory can 10 longer be used to interpret the dati, the Takagi-Taupin equations, which describe the x-ray field in strained crystals must be employed to analyse the data.

We report on XSW measurements on six InAsP/InP SL's exhibiting a wide range of misfit values using both (004) and (002) reflections; the same samples have also been studied by XAFS in a parallel investigation. Six InAsP/InP SL's were grown in the ÇSELT laboratories on InP(OOl). Typical period was 60 to 90 A, with the ternary layer accounting for 10 Å. As concentration in the ternary was between 0.05 and 0.40. The perpendicular lattice misfit varies between 0.3470 and *2.7970*.

Measurements were performed on ID 32, exploiting the high flux in order to excite the XSW field in the thin SL and the reduced divergence to obtain good phase contrast.

The XSW spectra are shown for all samples in the figure. The angular scale is referred to the substrate reflectivity peak; at the same angular position a symmetrical peak is observed in the XSW yield. This observation is compatible with the negligible coherent fraction expected for the As atoms, which are embedded in the SL structure, with respect to the XSW field set-up by the substrate. At smaller angular values, and at roughly the same position as the O-order SL reflectivity peak, a clear XSW signal is observed for samples 1-3. Assuming that the XSW field set-up here has a periodicity equal to the average SL (002) or (004) planes we conclude that we are observing XSW signals which give us information on the position of the As atoms with respect to these planes. For samples 4-6, which have a higher As concentration, the XSW signal is extremely small if not absent.

In order to analyze these spectra we have used the recursion solution to the Takagi-Taupin equations by assuming a model structure for each sample. In particular, the Ideal Uniform Abrupt SL (IUASL) model was assumed for the samples.




In order to simulate a XSW signal for the As some assumption must be made regarding the local structure in the ternary alloy. As a starting point we have chosen the Virtual Crystal Approximation (VCA): each atom is positioned in its ideal crystallographic position, i.e. that determined by elementary geometry by its two relevant lattice parameters ($a_\perp$ and $a_\parallel$). Using the two cited approximations we have simulated the As XSW signal for samples 1-3. Examples of the comparison between data and simulation for sample 1 are shown in bottom figure.

The results presented can be summarized in the following way: for samples 1-3 the simulation using the VCA and IUASL models reproduces very well the experimental lineshapes while samples 4-6, which exhibit a higher lattice misfit, have a very small signal and consequently a very low coherent fraction.

The result on the first three samples indicates that our method and underlying hypotheses are fundamentally correct. A detailed comparison indicates that the coherent position used is not perfectly adequate to reproduce the data; this is not surprising given the crudeness of the VCA. In these samples XSW can therefore give useful structural information.

The very small or absent signal on samples 4-6 indicates that coherent fraction of As in these samples is very small; these samples have a rather high misfit and therefore our result indicates the presence of interdifusion, roughness or lattice disorder due to the high accumulated strain.

These results have presented as an oral contribution at the XAFS 9 conference.