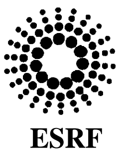

ESRF

Experiment title: Structure and roughness of strained InGaAs surfaces.		**Experiment number:** SI 214
Beamline: ID 3	**Date of experiment:** from: 23/10/97 to:30/10/97	**Date of report:** 1/9/97
Shifts: 18	**Local contact(s):** Xavier Torrelles	*Received at ESRF:* 5 SEP. 1997

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Due to difficulty in preparing the originally planned samples the experimental plan was changed and InGaAs surfaces were studied rather than InAsP ones; the scientific problem, i.e. the relationship between surface structure and bulk strain, is, however, identical.

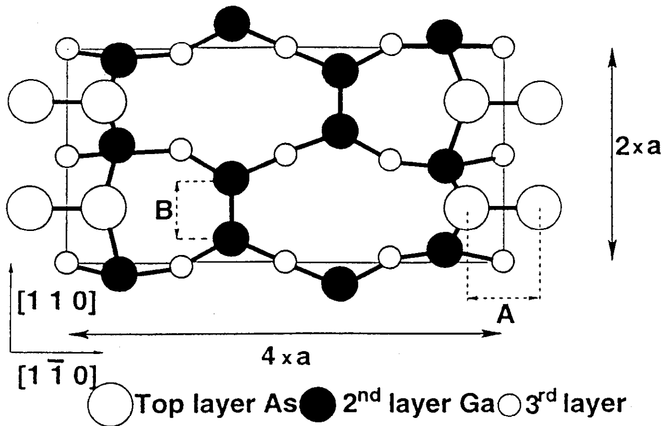
Recently, $In_xGa_{1-x}As/GaAs$ heterostructures have attracted interest for the production of lattice-matched substrates for the growth of ZnSe-based II-VI blue-green lasers [1, 2]. Because of the lack of II-VI substrates of suitable quality and doping, most such lasers have been fabricated by molecular beam epitaxy on GaAs wafers. ZnSe exhibits a 0.27% in-plane lattice-mismatch with GaAs, but is lattice-matched to $In_{0.038}Ga_{0.962}As$ [3], so that $In_{0.04}Ga_{0.96}As$ buffer layers grown on GaAs have already been incorporated in working lasers [2, 4]. Surfaces of strained III-V semiconductors are known to exhibit a cross-hatched morphology [5], related to the presence of strain-releasing dislocations, which is expected to play an important role in epitaxial growth processes. For these reasons the characterization of the surface structure and roughness of $In_xGa_{1-x}As$ buffer layers on GaAs is of great applicative importance; moreover there is a basic interest in studying the relation between surface structure and bulk strain.

$In_{0.04}Ga_{0.96}As$ layers were deposited on GaAs(001) by MBE in the INFM - TASC laboratories in Trieste and were capped by an amorphous As layer. Samples of thickness 100 nm, 300 nm and 2 µm were studied; these samples span the strain-relaxation transition and AFM investigations show that as the thickness increases clear, quasi-periodic, height modulations appear.

Samples were decapped in the ID 3 diffraction chamber and clear 4 x 2 surface reconstructions (with very weak 2-fold periodicity) were obtained, as observed by *in-situ* RHEED. These surfaces were studied by grazing-incidence X-ray diffraction, using a photon energy of 17.7 KeV; in-plane reflections, bulk CTR's and fractional order rods were measured.

All three samples have very similar diffracted intensities, independent of thickness; hence the degree of strain relaxation does not affect the surface structure at the unit cell level. The analysis of the in-plane data was performed with a novel application of "direct methods" [6] to surface crystallography. We are able to propose [7] a model for this surface which is a modification of the one by Skala et. al. [S], one of the models proposed for cation-rich GaAs(001) surfaces. In the figure we show a ball-and-stick rendering of our model.

Bulk CTR's of the three samples are very similar, indicating that X-ray diffraction (XRD) does not see appreciable differences in roughness. The apparent contradiction with the mentioned AFM data which shown the appearance of sinusoidal height fluctuations is under investigation, but must reside in the different lateral length scales probed by the two techniques [9], XRD being sensitive to shorter length scales than AFM; this indicates that the roughness seen by AFM is not present at short length scale.



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