ESRF	**Experiment title:** **Determination of the anisotropic in-plane strain in self-organized InAs Quantum Wires on InP**	**Experiment number**: HS933
Beamline: ID01	**Date of experiment**: from: 17/11/2000 to: 19/11/2000	**Date of report**: 02/02/02
Shifts: 9	**Local contact(s)**: Angel MAZUELAS	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

A. Mazuelas (1), L.Gonzalez (2), J.M. Garcia (2), and Y. Gonzalez (2)

(1) ESRF, BP 220, F-38043 Grenoble, France
(2) Centro Nacional de Microelectronica (CNM), Isaac Newton 8, E-28760 Tres Cantos, Spain

Introduction We have produced [1] ordered arrays of Quantum Wires (QWr) structures (>1µm long, 1-2 nm high, 8 nm wide) of InAs on InP by solid source molecular beam epitaxy (MBE), with the goal of fabricating structures emitting in the 1.5 µm wavelength range. The photoluminescence emission shows strong polarization dependence with respect to the orientation of the QWr, probably due to an asymmetric strain distribution in the QWr. Furthermore, strong optical anisotropy in the spectral region of the E_1 transition of bulk InAs was observed [2].

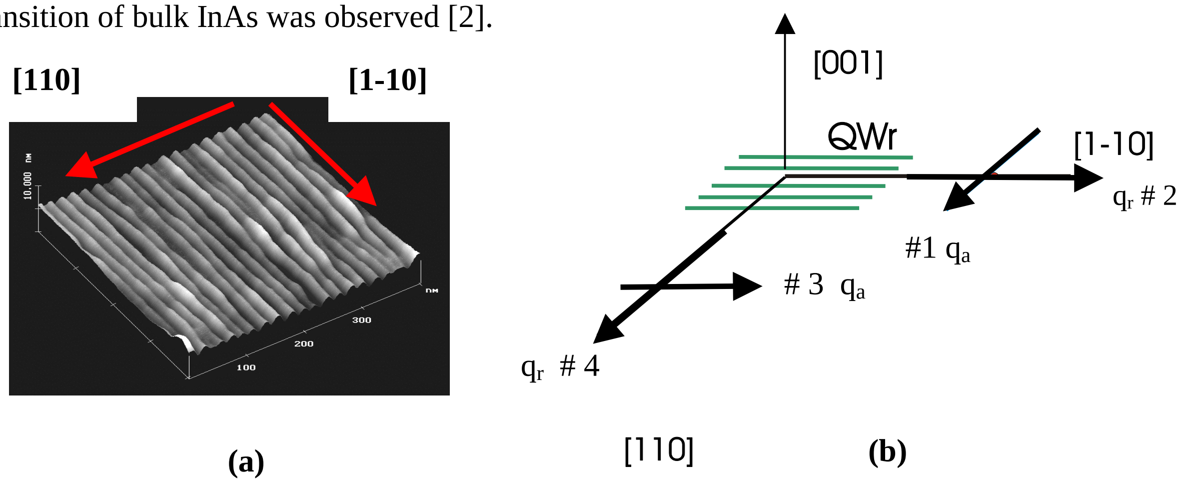

Fig. 1. AFM image of the morphology of the QWr (a), and schematic diagram of the scans performed in GID geometry (b) close to the 220 and 2-20 reflections. Radial scans, q_r are strain sensitive, angular scans, q_a are shape and correlation sensitive.

Experimental

We have used Atomic Force Microscopy (**AFM**) to measure the surface morphology, such as QWr density, size, shape and in-plane distribution. The QWr grow along the [1-10] direction and have an average lateral periodicity of 20 nm (Fig. 1a). No information on strain is obtained.

Triple crystal Grazing Incidence X-ray Diffraction (**GID**) was applied to determine the shape, lateral correlation and the strain parallel and perpendicular to the QWr. The scans performed in reciprocal space are shown schematically in Fig 1b. We make radial and angular scans near the (220) and (2-20) reflections (marked #1-4 in Fig. 1b). Angular scans are interpreted in terms of shape and lateral correlations. The intensity in radial scans is, in addition, strain sensitive. Measuring angular and radial scans, both parallel and perpendicular to the QWr enables us to separate the shape, correlations and strain.

Simulations of both the radial and angular scans are in progress, here we present a preliminary interpretation. In figure 2a) an angular scan with q_a perpendicular to the QWr direction is shown. Two peaks are found which are due to lateral ordering of the QWr. The intensity (I) is fitted by the product of the shape (S) and correlation (C) functions. The fit indicates the period to be 20 nm (in good agreement with the determination by AFM). In a radial scan with q_r along the QWr axis (Fig. 2b), only the Bragg peak corresponding to the InP substrate (2-20) is found. This means that along the QWr the InAs is coherently strained to match the InP lattice parameter (5.868 Å), corresponding to 3.2% strain. Scan #3 is an angular scan with q_a parallel to the QWr. We obtain no correlation or shape dependent intensity, which means that all QWr are aligned along the [1-10] direction.

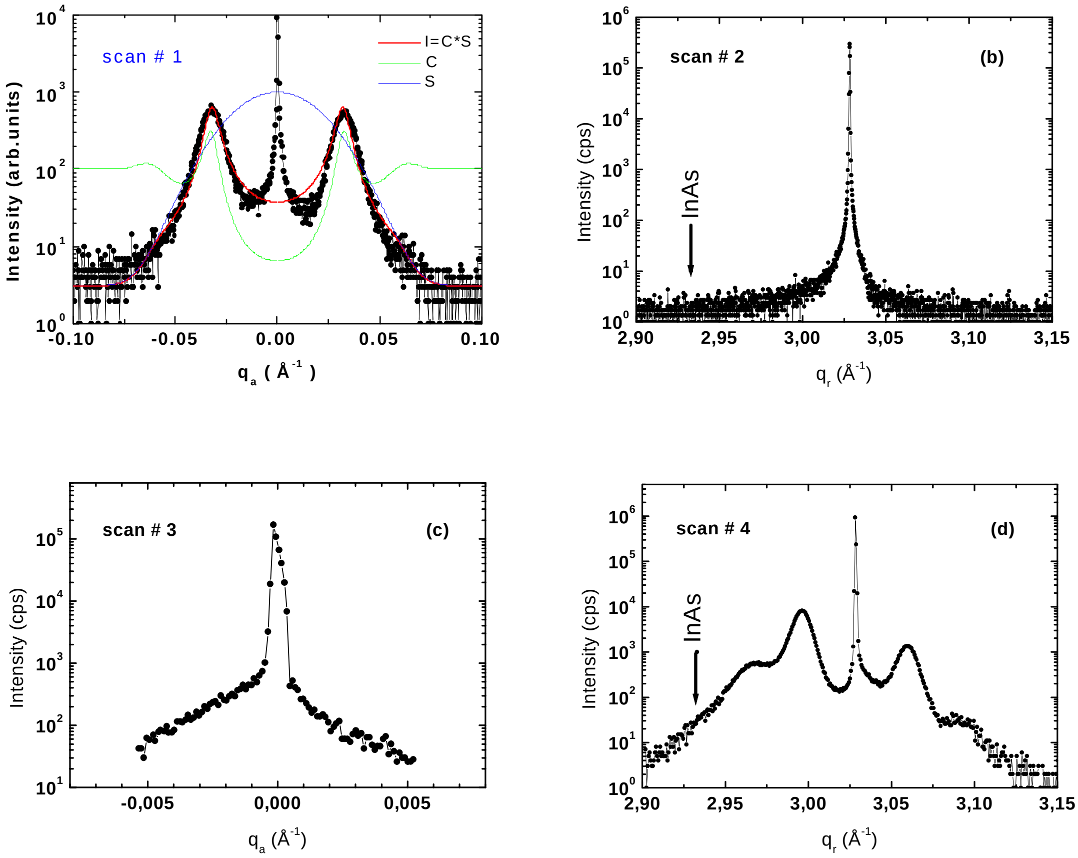

Fig. 2. Angular scan perpendicular to the QWr (a), radial scan along the QWr (b), angular scan along the QWr (c), and radial scan perpendicular to the QWr (d). In (b) and (d) the arrows indicate the position of a relaxed InAs layer.

In Figure 2d) a radial scan with q_r perpendicular to the QWr direction is presented. Here the shape and correlation functions are modulated by the strain. We observe that the intensity profile is asymmetric with respect to the sharp substrate (220) peak, indicating strain relaxation towards the lattice parameter of InAs. In addition we observe a strain induced broadening of the intensity distribution due to a lattice parameter distribution in the QWr varying from the bottom to the top of the QWr.

We also performed reciprocal space maps around the (2-20) reflection. From the section of the correlation maxima along the [1-10] direction (Fig.3.), we obtain the length of the QWr to be 220 nm.

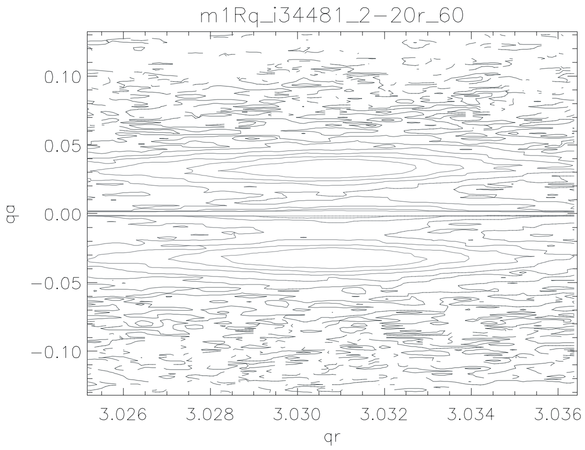

Fig.3. Reciprocal space map around the (2-20) reflection with the correlation maxima. From the correlation peak widths along the [1-10] direction (horizontal line), the length of the QWr is found to be of 220 nm

Simulations of the intensity distribution in the four scans are in work and will result in a quantitative description of strain, shape and ordering of these unique quantum wires.

References

1. L.González, J.M.García, R.García, F.Briones, J. Martinez-Pastor, and C. Ballesteros, Appl. Phys. Lett. **76**, 1104 (2000).
2. J.A.Prieto, G. Armelles, C. Priester, J.M. Garcia, L. Gonzalez, and R. Garcia, Appl. Phys. Lett. **76**, 2197 (2000)