ESRF	**Experiment title:** Strain and shape analysis of stacked quantum wire arrays with widths of 43 nm before and after overgrowth	**Experiment number**: HS-1276
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Report:

Quantum wires are introduced into semiconductor lasers to improve their parameters e.g. to lower their threshold voltages and increase the thermal stability. The investigation of quantum wire structures is part of a collaboration with Tokyo Institute of Technology where the samples were grown. We continued the characterization of unstacked wire arrays with wire widths of 35 nm and a wire thickness of 10 nm which have been investigated by coplanar diffraction experiments in experiment SI-500 (in 1999). The InGaAsP wires are compressively strained by about 1% with respect to the InP substrate. As expected the free standing wires clearly exhibit an elastic relaxation of the stress inside the wires. After covering the wire grating with material nominally lattice matched to the substrate a reduction of the stress relaxation is observed. In order to obtain depth dependent information about the strain in the samples we performed grazing incidence diffraction (GID) measurements during the present experiment. First we measured the “strain sensitive” (2 2 0) reflection: The longitudinal scan parallel to the reciprocal lattice vector and perpendicular to the lines of the grating shows the superstructure maxima due to the wire grating which are influenced by the lateral strain in the structure. We see in the Figure 1 (a), that the strain in the overgrown sample is nearly independent of the glancing angle of incidence α_i (and hence of the penetration depth) of the radiation up to $\alpha_i = 0.32°$ (up to a penetration depth of about 200 nm). This suggests, that not the local deformations InGaAsP quantum wires themselves are responsible for the strong superstructure maxima in the (2 2 0) GID reflection, but their far reaching deformation field together with the unintended small misfit between the cover layer and the wire grating (overall etching depth of the grating about 60 nm). For the free standing wires the intensity distribution is clearly changing with the angle of incidence α_i (see Figure 1 (b)).

We have seen an influence of strongly mismatched cover layers (in experiment HS-398 in 1998 [1]) on the diffraction pattern and on the photoluminescence (PL) line shift. The quality of the samples has been improved considerably in the mean time, although a remaining very small misfit of the cover layer ($\Delta a/a$ lower than 0.5 10^{-3}) could be found (also in usual diffraction experiments at unstructured regions of the samples). Photoluminescence of the samples has been measured recently as described in [1]. In this way we hope to distinguish between the effects of strain and quantum size of the wires by comparing the measured deformation field inside the wires to the shift of the PL line. In addition we recorded reciprocal space maps in the "strain insensitive" (2 –2 0) reflection (with longitudinal scans, which do not show superstructure maxima) for different penetration depths and found a depth dependence of strain along the wire direction with a maximum of strain at the wire depth. This effect should not occur for ideal wires, and can be explained only in terms of lateral inhomogeneities of the wires themselves or of the cover layer.

[1] D. Luebbert, B. Jenichen, T. Baumbach, H.T. Grahn, G. Paris, A. Mazuelas, T. Kojima, and S. Arai, J. Phys. D **32** (1999) A21

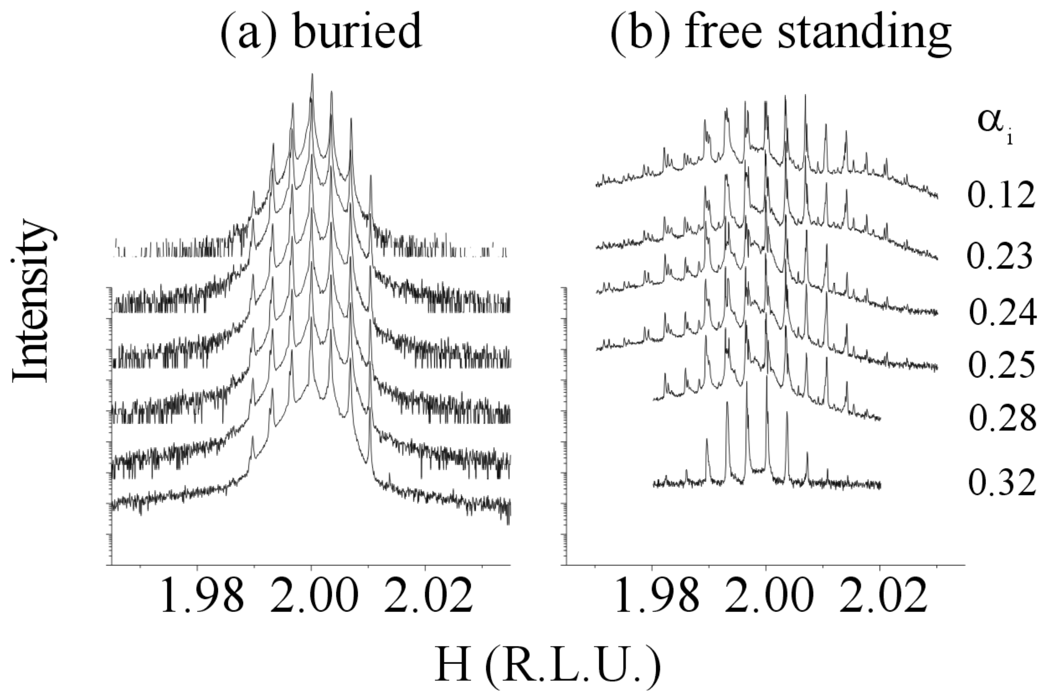

Fig. 1: Distributions of the intensity of grazing incidence diffraction in the (2 2 0) reflection, longitudinal scans accross the grating lines parallel to the scattering vector. By variing the glancing angle of incidence α_i the penetration depth of the radiation is changed (corresponding α_i are given). Buried and free standing quantum wire structures are compared.

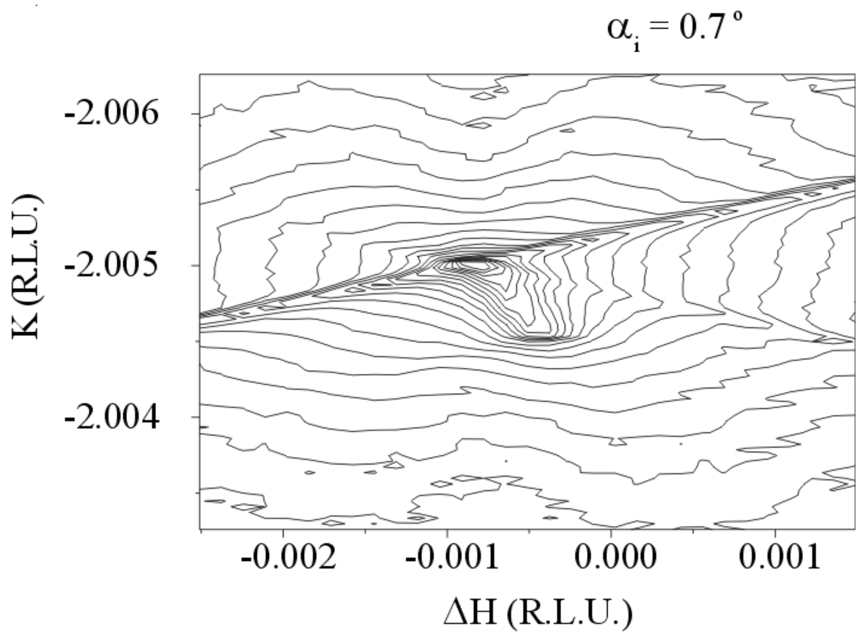

Fig. 2: Reciprocal space map of grazing incidence diffraction, (2 –2 0) reflection not sensitive to strain perpendicular to the wires, the grazing incidence glancing angle is α_i= 0.7°. This angle is roughly corresponding to the wire depth below the surface. The bump near (0, -2.0045) is probably due to an (unexpected) component of the strain along the wire direction. The large cross is the resolution function of the triple crystal arrangement.