| ESRF | **Experiment title:** Strain and shape analysis of quantum wire arrays with widths of 35nm before and after overgrowth | **Experiment number:** SI-500 |
|---|---|---|
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**Report:**

High resolution X-ray diffractometry in an asymmetric geometry has been used to compare the effects of elastic stress relaxation of free standing and overgrown $Ga_{0.22}In_{0.78}As_{0.80}P_{0.20}$ quantum wire structures on InP. The individual wires have a width of 35 nm and a thickness of 10 nm. The region of diffraction of the strained wires is well separated and evidences some relaxation of the stress in the wires. This elastic relaxation occurs near the free surface of the sidewalls in the free standing structures. Surprisingly the overgrowth of the structures with a nominally lattice matched layer, which nevertheless has some residual tensile strain compared to the InP substrate, does not lead to the expected reduction of the relaxation effects. In addition, the diffuse scattering increases in the overgrown structures. Three reciprocal space maps and many scans along and across the grating truncation rods were measured in the asymmetric 224 reflection with grazing exit.

Figure 1(a) shows the reciprocal space map of the free standing wire structures. The regular pattern of vertical grating truncation rods comes from the lateral periodicity. The trapezoidal shape of the grating ridges is obvious from the inclined diffuse rods perpendicular to the surface of the sidewalls. Figure 1 (b) demonstrates a map of the same wire structure overgrown at 600°C. Clearly distinct wire regions are visible in Figs. 1 (a) and 1 (b) at $Q_z \approx 4.22/Å$ and $Q_x \approx 3.02/Å$. Figure 2 shows the result of a calculation of an ideally overgrown structure. The strain fields in the wire structures are determined, and the diffraction patterns are derived from the strain maps in the kinematical approximation.

Fig. 1

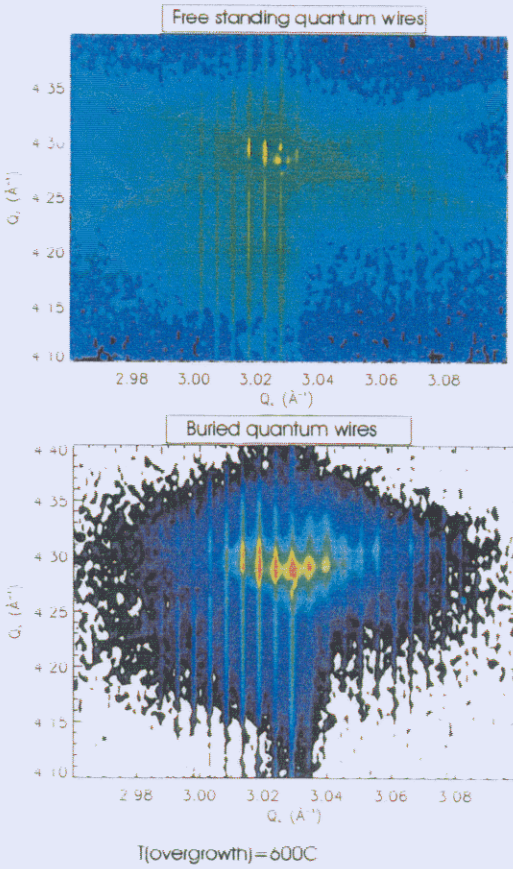
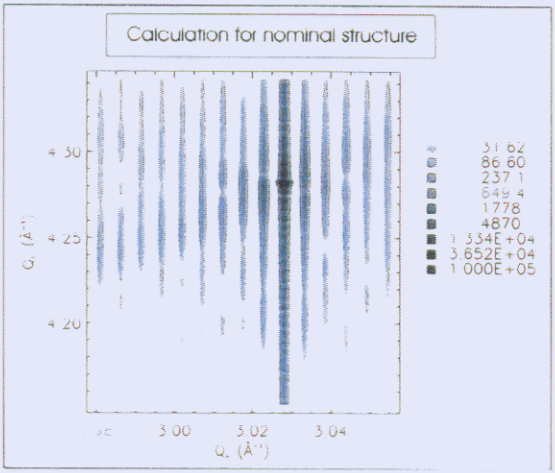

(a)
Free standing quantum wires
4.35
4.30
4.25
4.20
4.15
4.10
Q_z (Å⁻¹)
2.98
3.00
3.02
3.04
3.06
3.08
Q_x (Å⁻¹)
(b)
Buried quantum wires
4.40
4.35
4.30
4.25
4.20
4.15
4.10
Q_z (Å⁻¹)
2.98
3.00
3.02
3.04
3.06
3.08
Q_x (Å⁻¹)
T(overgrowth)=600C

Fig. 2


Calculation for nominal structure
4.30
4.25
4.20
Q_z (Å⁻¹)
3.00
3.02
3.04
Q_x (Å⁻¹)
31.62
86.60
237.1
649.4
1778
4870
1.334E+04
3.652E+04
1.000E+05