Generalized-GIXD (Evanescent Scattering) measurements of InAs nano-dots

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Introduction

Generalized grazing incidence-angle x-ray diffraction (G-GIXD) or evanescent scattering has been developed to investigate near surface structures of films and dots on Si [1-3]. In this study, this technique has been applied to nano-dots of InAs to investigate change of in-plane structures along the depth-direction.

Experiments

The method was applied to nano-dots of InAs, ~ 20^{H}x$30^{\phi}$$nm^3$, grown on Si (001) [3]. Evanescent scattering was measured by keeping the angle of incidence (α_i) around the critical angle of InAs (α_c). Bragg spots were measured systematically by mesh scanning with a scintillation counter (SC)in the Q-space : Q-components parallel (Q_{x-y}) and perpendicular (Q_z) to the surface, where outline of the profile was also measured by an image plate. Two sets of slits, which limit the height and the width of the beam path, are positioned in front of SC. Resolution function was changed by altering the heights (h_{slit}), the width (w_{slit}), and the distance of two slits (d_{slit}). The typical values are : h_{slit} w_{slit} and = 1-2 mm, d_{slit}= 310 mm; the resolution are ΔQ_{x-y} = $1\text{-}2\times10^{-2}$ and $\Delta Q_z = 2\text{-}4\times10^{-2}$ [r.l.u.]. Typical time for measuring intensities by SC was about 1-10 sec. Experiments have been carried out at BL-3A.

Results

Fig.1 shows the α_i dependence of 220 (in-plane) scattering profiles of InAs which corresponds to the Q_{x-y} cross-section of $Q(\mathbf{k})$ at Q_z = 0.0. It is clearly observed that the peak maximum shifts towards at a larger Q_{x-y} side as increase of α_i , showing the existence of the gradient of the strain field. The scattering intensities are maximum at the condition $\alpha_I = \alpha_c$, and their change is consistent with the calculated one. This indicated that the measured intensities come from the evanescent scattering and are not caused by bulk scattering at the side sections of dots.

The strain field in the Q_{x-y} direction is calculated from measured intensities. Fig.2 shows the penetration depth: $l_{1/e}$ dependence of the strain of InAs nano-dots, where the $l_{1/e}$ = 0 and = 35 nm corresponds the top and the bottom (or the interface of InAs/Si) of the dots. It is worth noting that the measured strain is the sum of the total region of penetration. The strain is saturated around a depth $l_{1/e}$ = 35 nm, because the region $l_{1/e}$ > 35 nm corresponds to the substrate of Si. It is revealed the strain is maximum at the interface InAs/Si and the averaged strain ε_{x-y} = -0.5 % and that the strain is relaxed near the top.

The intensities of evanescent wave decays as a function of $\exp(-z/l_{1/e})$ (z: depth). The deconvolution of measured strain which was averaged over the depth, can be performed using FEM technique based on the results for different α_i [4].

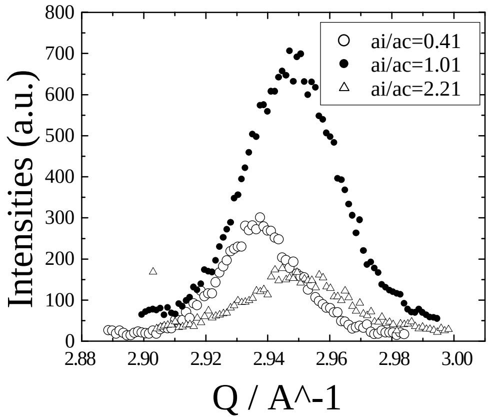

Fig.1 α_i dependence of 220 (in-plane) scattering profiles of InAs

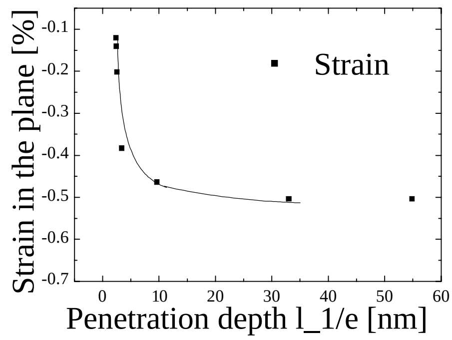

Fig.2 Penetration depth: $l_{1/e}$ dependence of the strain of InAs nano-dots.

References

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