Measurement of local strain and atomic distribution in InGaAs/GaAsP Multi-quantum well

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Introduction.

Strained layer Multi-Quantum Well (MQW) became one of the key structures in opto-electronic field major field because of its capacity and flexibility of controlling parameters. [1] Compositionally different MQW inevitably encounter internal strain field, which can be a favorable driving force for the individual elements to be mixed. Depending on the dominance of the chemical bonding and the strain relaxation introduced by the difference of the lattice parameters, optical parameters, such as interface sharpness, effective bandgap, are greatly influenced.

Experimental.

GaAsP and InGaAs MQW structure, 30 layers of alternating layers as shown in the inset of figure 1(a) was grown in chemical vapor deposition system at 650 °C. Cross-sectional transmission electron microscopy specimen wasprepared using typical gluing and grinding followed by ion milling and final cleaning with 1kV Ar ions. For high angle annular darkfield (HAADF, also known as Z-contrast) observation, scattering angle higher than 20 mrad diffractions wasused to get atomic mass-dependent information. The quality of MQW was confirmed using the satellite peaks in high resolution X-ray diffraction (XRD).

Results and Discussion.

Figure (1) shows the result of XRD scanned from ± 1degree from GaAs [400] peak position. Right above the experimentally obtained XRD pattern of GaAsP/InGaAs MQW, simulated peaks are shown. Simulation parameters in this simulationwere GaAsP and InGaAs layer thicknesses were 142 and 60 nm, respectively, and the best fitting was obtained using periodicity of 35 nm. In the figure, the extra peak, marked with an arrow, was observed in the experimental data which is not visible in the simulated peak positions. In order to identify the source of the extra peak observed in the XRD, Quantitative microstructural investigation was made using HAADF. The contrast

obtained from HAADF is known to be sensitive to the atomic mass [2] and it is suggested that the quantitative information can be extracted.[3] Cross-sectional HAADF view of the samples is shown in Figure 2(a) and the change of the electron density across the layers was shown in the figure 2(b). Electron density plot in the figure 2(b) reveals distinct change in the curvature in between layers, which is quite different from the profile across the sharp interface induced by the scanning electron probe size in the HAADF image, which is shown as dotted line. Relative mixing of the elements were calculated assuming the linear relationship of scattering power and atomic composition. The results of relative elemental distribution were shown in the figure 2(c).In this figure 2(c), Phosphorous (P) are depletes in GaAsP region to reduce the strain. Obtained from intermixing ratio, relaxation is moving toward the tendency to reduce the strain.

Reference.

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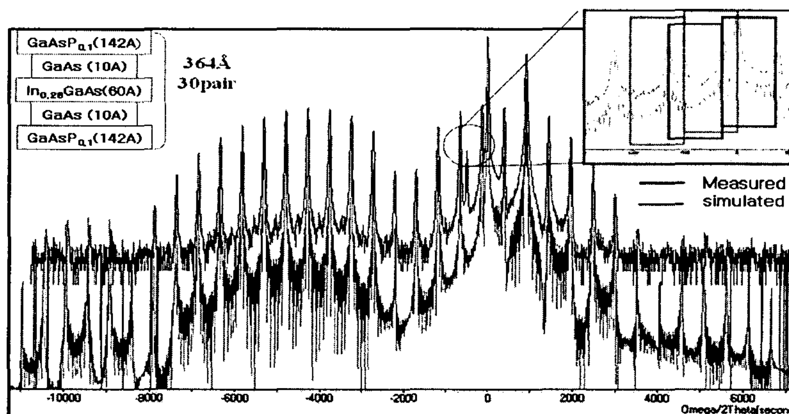

Figure (1). The result of XRD scanned from ± 1degree from GaAs [400] peak position.

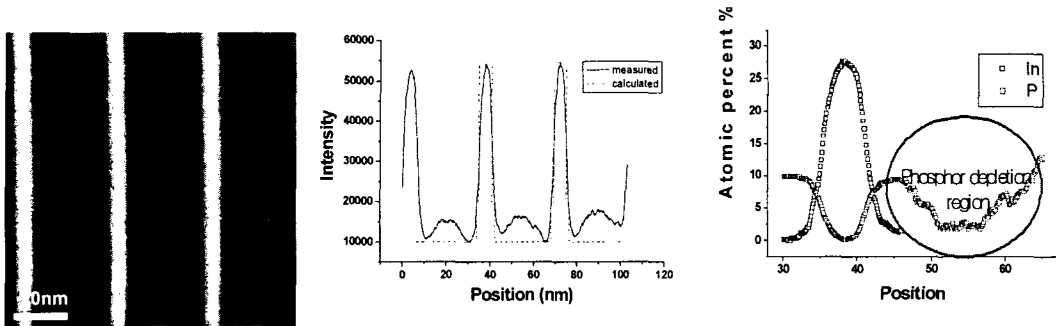

Figure 2 (a) Cross-sectional HAADF view of the samples (b) the change of the electron density across the layers (c) The results of relative elemental distribution of In and