

Lattice vibrations study of $\text{Ga}_{1-x}\text{In}_x\text{As}_y\text{Sb}_{1-y}$ quaternary alloys with low (In, As) content grown by liquid phase epitaxy

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Abstract. Raman scattering spectroscopy was used to measure and analyze the lattice vibrations in some quaternary $\text{Ga}_{1-x}\text{In}_x\text{As}_y\text{Sb}_{1-y}$ alloys with low (In, As) contents, ($0.03 < x < 0.12$ and $0.03 < y < 0.10$). The layers were grown by liquid phase epitaxy on (001) GaSb substrates at 540 °C. High Resolution X-Ray Diffraction results showed profiles associated with a quaternary layer lattice matched to the GaSb substrate as obtained from the (004) reflection. The experimental diffractograms were simulated to estimate alloy composition, thickness and lattice mismatch of the layer. Raman scattering results show phonon frequencies associated to the TO and LO GaAs-like modes as well as GaSb+InAs-like mode, which are characteristic of this quaternary alloy. The As content dependence of the phonon frequency measured in this alloy for low (In, As) contents agree well with the modified Random-Element Isodisplacement (REI) model and also with other available experimental reports. This method can also be used to estimate alloy compositions for this kind of quaternary alloys.

1. Introduction

The quaternary GaInAsSb alloy lattice matched to GaSb is a narrow band-gap semiconductor (0.3-0.7 eV) with a number of applications including thermophotovoltaic cells [1], infrared light-emitting diodes [2] lasers [3] and photodetectors [4]. The growth of this alloy, however, is fundamentally difficult because of the existence of a large miscibility gap [5]. Metastable alloys have a tendency to decompose into regions with non-uniform alloy composition which is undesirable due to the degradation of the structural [6], optical [7] and electrical [8] properties. The growth of GaInAsSb alloys by LPE (Liquid Phase Epitaxy) [9], MOCVD (Metalorganic Chemical Vapor Deposition) [10], MBE (Molecular Beam Epitaxy) [11], and LPEE (Liquid Phase Electroepitaxy) [12], has been reported. For this reason it is important to know about the structural properties of this kind of quaternary alloy. Only a few number of papers report studies on the vibrational properties of GaInAsSb [13, 14, 15] which give important information on some structural properties of this system. Kleinert [13] reported theoretical studies of infrared absorption spectra of GaInAsSb by using the mean-field approximation. Jaw et. al. [14] applied a modified random-element (REI) model developed by them to calculate the frequency shift of the TO and LO modes of GaAs, GaSb, InAs and InSb lattice vibrations in the quaternary alloy. More recently Vorlíček et. al. [15] reported vibrational properties of GaInAsSb grown on GaSb by LPE using the Raman scattering technique for an As content between 0.13 and 0.26. In this work, the optical lattice vibrations for low (In, As) content in $\text{Ga}_{1-x}\text{In}_x\text{As}_y\text{Sb}_{1-y}$ alloys ($0.03 < x < 0.12$ and $0.03 < y < 0.10$) grown on (001) GaSb substrates by liquid