Arsenic Pressure Dependence GaAsBi/GaAs Growth on (411)B and (100) GaAs Substrates by Molecular Beam Epitaxy

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The III-V semiconductors grown with Bi have numerous benefits, including surface smoothing and band gap reduction; such characteristics are favorable for developing long wavelength optoelectronic devices. Bismuth does not desirably incorporate into GaAs due to its large atom size, approximately 25% larger than Ga and As, and tends to surface-segregate during growth. For this reason the growth of GaAsBi requires very low growth temperatures (<400°C) to incorporate significant amount of Bi. The optical properties and amount of Bi incorporation is not only sensitive to the arsenic pressure during growth but also to the substrate orientation.

In this work, GaAsBi was grown by molecular beam epitaxy on (411)B to study the incorporation of the Bi atom on high orientation substrate and compared with (100) GaAs substrates. The surface morphology of GaAsBi was observed by optical microscope images (OMI). The Bi incorporation into GaAs was investigated by x-ray diffraction (XRD). Optical properties are characterized by photoluminescence (PL).

Three GaAsBi (7 nm) / GaAs (11 nm) MQWs samples were grown under different As₄ pressures (2.0 x 10⁻⁵ mbar, 1.0 x 10⁻⁵ mbar and 6.0 x 10⁻⁶ mbar) on semi-insulating high index surface (411)B and (100) GaAs substrate using an MBE system. Eleven periods of GaAsBi/GaAs pairs were grown at T_{GaAsBi} = 350°C and T_{GaAs} = 550°C.

(411)B and (100) samples shows smooth and flat surface morphology for high As₄ pressures (2.0 x 10⁻⁵ mbar, and 1.0 x 10⁻⁵ mbar) growths, but at low (6.0 x 10⁻⁶ mbar) As₄ pressure (411)B and (100) samples are observed with rough surface. The sharp and clear satellite peaks are observed from both (411)B and (100) samples grown at 1.0 x 10⁻⁵ mbar as compared to those grown at 2.0 x 10⁻⁵ mbar and 6.0 x 10⁻⁶ As₄ pressure which indicating higher and uniform incorporation of Bi atoms. The As₄ dependent Bi incorporation of GaAsBi/GaAs MQWs on (411)B is shown by HRXRD patterns of θ- 2θ scans from (004) reflection as shown in Fig. 1. The PL emission peak from (411)B and (100) is also observed at 1142 nm 1114 nm respectively at (1.0 x 10⁻⁵ mbar) As₄ pressure. The value of photon energy is ℎν = 1.08 eV with high PL intensity and narrower linewidth. The result obtained from (411)B sample indicates, 1.0 x 10⁻⁵ mbar As₄ pressure optimal growth parameter for (411)B, and it is applicable in light emitting diode and laser application to achieve longer wavelength.

![Fig. 1 HRXRD spectra from (411)B GaAsBi/GaAs MQWs dependent on As₄ pressure](image-url)