MBE growth for high quality GaAsBi/GaAs MQWs for longer wavelength emission

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The III-V semiconductors gain attention in the 1.3–1.5 μm wavelength range are currently under intense investigation because of the important role of lasers in optical fiber communications, specially grown with Bi have numerous benefits, such as surface smoothing owing to its surfactant effect, large band gap reduction and temperature insensitive band gap. Such characteristics are favorable for developing long wavelength optoelectronic devices. GaAsBi/GaAs multi quantum wells (MQWs) are of interest for the fabrication of laser diodes. However, the incorporation of Bi into MQWs is more complicated than into bulk alloys than that of conventional III–V alloys, e.g., like InGaAs or AlGaAs.

In this work, we focus on the growth of p-i-n type GaAsBi/GaAs MQWs on n-type (100) GaAs with large Bi contents at a substrate temperature of 350°C for GaAsBi and 550°C for GaAs layer. The growth parameters were précised from our previous report on eleven periods of GaAsBi/GaAs MQWs on semi insulating GaAs (100) with 3.8% Bi incorporation at optimum As_4 BEP with 9 nm GaAsBi and with barrier of 14 nm GaAs layer alternating. To obtain desired long wavelength emission, we grew eleven period MQWs with increase in GaABi as 11.8 nm, separated by GaAs 11.8 nm barriers stacked in between 600 nm GaAs layer. These samples MQWs i-region were grown under identical conditions as previous MQWs at an As_4 flux of 1.0×10^{-5} mbar and 8.5×10^{-7} mbar and 5.4×10^{-7} mbar for Ga and Bi, respectively. A 600 nm n-type (GaAs:Si) and p-type (GaAs:Be) buffer layer was grown at 580 °C. The layers were characterized by high resolution x-ray diffraction (HRXRD) and reciprocal space mapping (RSM) for and asymmetric reflection. HRXRD spectra fitted using Epitaxy software to determine Bi composition and epilayer thicknesses assuming a GaBi lattice constant of 6.324 Å as zinc blend structure. The photoluminescence (PL) measurements were conducted at 10K with laser excitation of 3.8 mW power and its spot diameter of 200 μm.

Figure 1 showed HRXRD scans around GaAs 004 reflection with simulation fitting that these sample kept their constituents well defined clear satellite peaks, suggesting growth concept lead to regular eleven period MQWs structures, GaAsBi layer having abrupt interfaces, assume that Bi atoms are evaporated with increasing the substrate temperature prior to the growth of GaAs layer and uniformly distributed in GaAsBi layers having a steep composition profile in simulation. In HRXRD RSM, also reveals that constituting layers are grown without strain relaxation. We observed red shift compared to previous result; the sample shows ~1.2 μm wavelength emission at 10K with narrow FWHM of 64 meV for 4.2% Bi incorporation indicating that GaAsBi/GaAs MQWs with effectively narrow energy gap material. This result indicates that GaAsBi MQWs by MBE is expected to have better performance optical devices at room temperature.

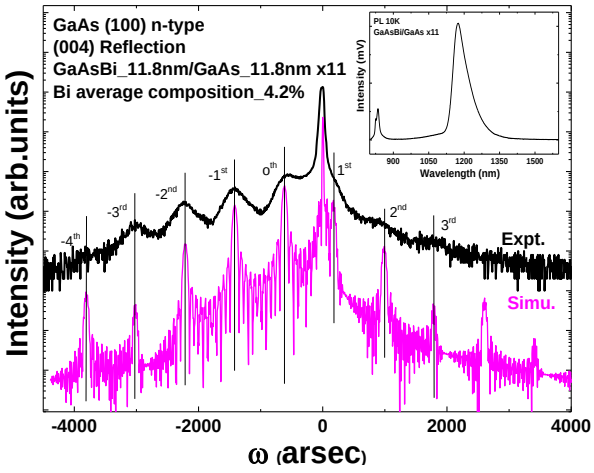

Fig. 1 HRXRD spectra p-i-n type GaAsBi/GaAs MQWs on n-type (100) GaAs 4.2% large Bi contents with insert PL spectra at 10K