Molecular beam epitaxial growth and characterization of $GaAs_{0.5}Sb_{0.5}$ layers on (111)B InP substrates

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$GaAs_{0.5}Sb_{0.5}$ lattice matched to InP substrates is a promising material for new photonic devices based on InP. For example, $In_{0.53}Ga_{0.47}As/GaAs_{0.5}Sb_{0.5}$ type Ⅱ quantum well structures lattice-matched to InP substrates are very attractive for mid-infrared lasers for chemical sensing and medical diagnostics[1,2]. However, there has been no report concerning the epitaxial growth of the GaAsSb layers on (111) oriented substrates. This paper reports the molecular beam epitaxial (MBE) growth and characterization of $GaAs_{0.5}Sb_{0.5}$ on (111)B InP substrates.

The $GaAs_{0.5}Sb_{0.5}$ were grown on Fe doped semi-insulating (111)B InP and (100) InP substrates by solid source MBE. The growth temperature was 505℃. In and Ga metals were used as groupⅢ beam sources , while tetramers As_4 and Sb_4 were used for groupⅤ beam sources. The V/III ratio (As_4 + Sb_4)/Ga was varied from 5.5 to 18.0 by changing the As beam intensity from $3x10^{-6}$ to $1.2x10^{-5}$ Torr.

Figure 1 shows the Sb mole fraction in the GaAsSb layers as a function of the As beam intensity, where the Ga and Sb beam intensities were kept constant. It is known that the Sb mole fraction of the (111) samples is larger than that of the (100) samples. This means that the Sb incorporation rate of the (111) surface is larger than that of the (100) surface. Atomic force microscopy (AFM) observation revealed that the mirror surface was obtained only when the V/III ratio =12.0 (As beam intensity = $8x10^{-6}$ Torr) in the case for the (111)B samples. On the other hand, all of the (100) samples have mirror surfaces.

Photoluminescence (PL) measurements were carried out at 77K. It was found that PL was observed only when the V/III ratio =12.0 in the case for the (111) samples, which corresponds to the V/III ratio dependence of the surface morphology. Figure.2 shows the PL spectrum of the GaAsSb layers grown on (111)B InP substrates and (100) InP substrates with the V/III ratio of 12.0. It is known that the peak wavelength of the (111) sample (1.46 μm) is shorter than that of the (100) sample (1.54 μm), despite of the larger Sb mole fraction in the (111) sample.

The band gap energy shift was also realized for the optical absorption spectrum. Fig.3 shows the absorption spectrum of the GaAsSb layers grown on (111)B InP and (100) InP substrates at 300K. It is clearly seen that the absorption edge of the (111) sample is shorter than that of the (100) sample, which corresponds to the result of the PL spectrum. This energy shift observed in the (111) sample is probably induced by the decrease in the spontaneous ordering, which is considered to exist in the (100) samples.

[1] M. Peter, R. Kiefer, F. Fuchs, N. Herres, K. Winkler, K.-H. Bachem, and J. Wagner, Appl. Phys. Lett. 74 (1999) 1951
[2] H. Takasaki, Y. Kawamura, T. Katayama, A. Yamamoto, H. Naito, and N. Inoue, Applied Surface Science 159/160 (2000) 528

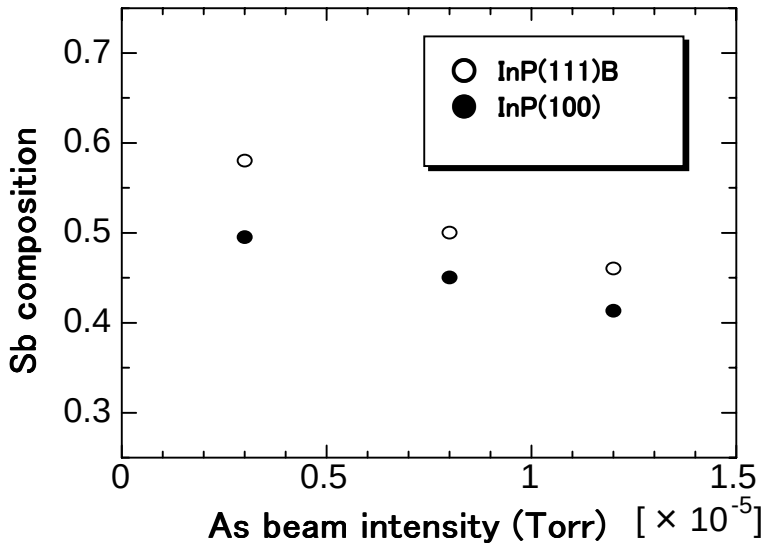

Fig.1 As pressure dependence of Sb composition

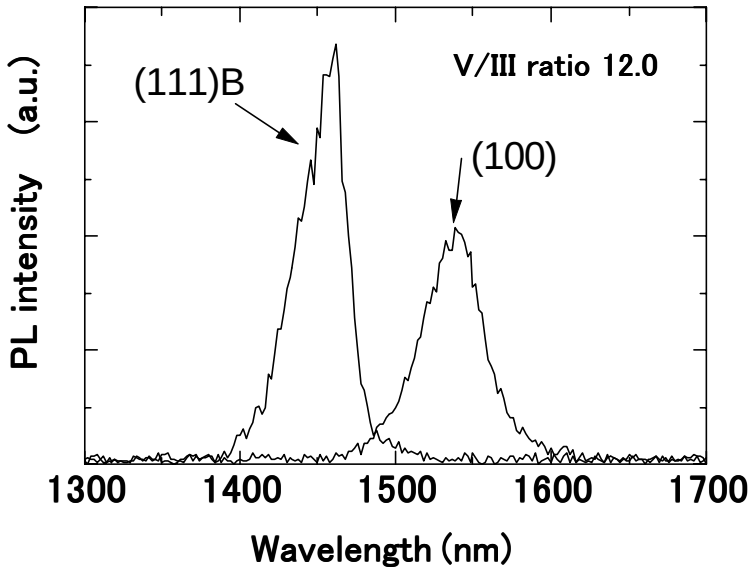

Fig.2 PL spectrum of GaAsSb on InP(100) and InP(111)B

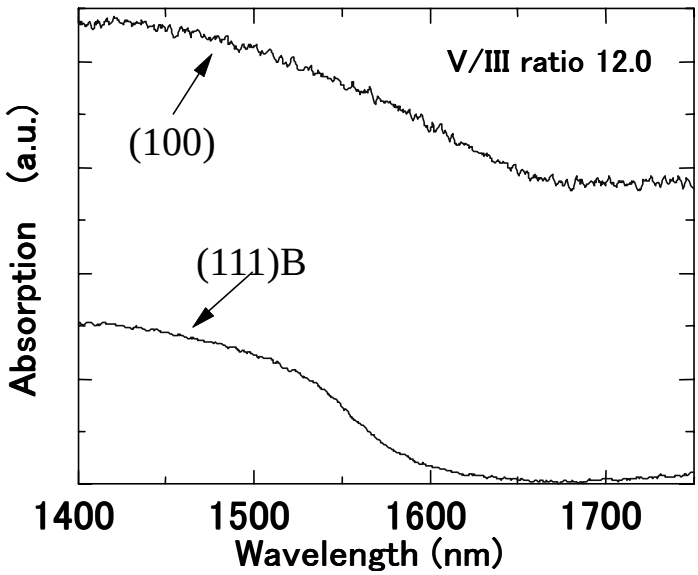

Fig.3 Absorption spectrum of GaAsSb on InP(100) and InP(111)B