Temperature-stable wavelength TlInGaAs/InP DH LEDs grown by gas source MBE

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TlInGaP and TlInGaAs were proposed as new semiconductors showing temperature-independent bandgap energy at some alloy compositions for the possible application to the temperature-stable wavelength laser diodes (LDs) [1,2]. These LDs are important in the wavelength division multiplexing (WDM) optical fiber communication system. We have already succeeded in the growth of TlInGaAs/InP double heterostructures (DHs) and for the DH with a Tl composition of 13% we observed very small temperature variation of the photoluminescence (PL) peak energy as small as 0.03 meV, which corresponds to the PL wavelength variation of 0.04 nm/K [3]. This value is much smaller than that (0.1 nm/K) of the lasing wavelength of InGaAsP/InP DFB laser diodes.

In this paper, we will report on the successful growth of TlInGaAs/InP DH light emitting diodes (LEDs) by gas source MBE and the observation of small temperature variation of the electroluminescence (EL) peak energy.

TlInGaAs/InP DH LED samples were grown on Si-doped (100) InP substrates at 450℃. Elemental Tl (5N), In (7N) and Ga (7N) and thermally cracked AsH_3 and PH_3 were used as group III and group V sources, respectively. They are composed of Si-doped InP cladding layer, undoped TlInGaAs active layer, Be-doped InP cladding layer and Be-doped InGaAs cap layer, as shown in the inset of Fig. 1.

The 100 μm diameter p-type electrode was formed on the top p-type InGaAs cap layer. The light output was detected form the top surface. For the LEDs with a 6% Tl composition TlInGaAs active layer, the light output varied linearly with current up to 200mA (DC) at room temperature (Fig.1). For this LED, small temperature variation of the EL peak energy was observed at 100-340K (Fig.2). The temperature variation of the EL peak energy (-0.09meV/K) for the TlInGaAs/InP DH LED with a Tl composition of 6% was very similar to that of PL peak energy for the same DH wafer as shown in Fig.3(a), where the temperature variation of PL peak energy for the DH with a Tl composition of 13% is also shown for comparison. The temperature variation of the EL intensity was much smaller than that of the PL intensity (Fig.3 (b)). This difference is considered to be due to the difference in the injection process of carriers; in the PL measurement the carriers are excited mostly in the upper InP cladding layer and diffuse into the TlInGaAs active layer, while in the EL measurement they are directly injected into the TlInGaAs active layer through the p-n junction. The results are very encouraging and are the great first step to realize the temperature-stable wavelength LDs.

References

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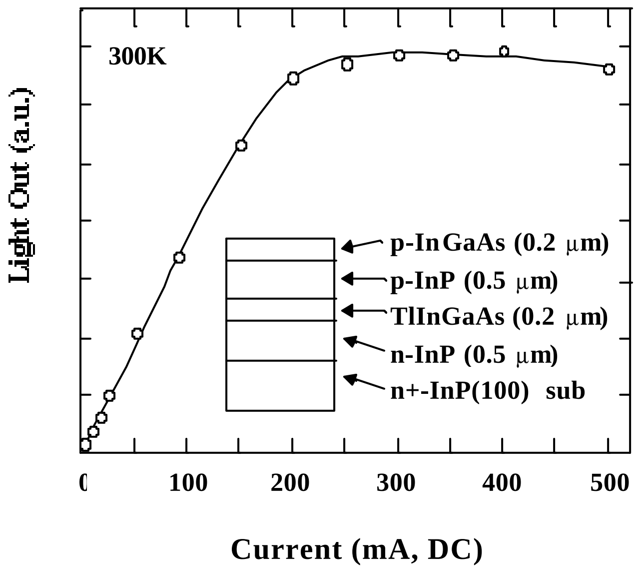

Fig.1 Sample structure of TlInGaAs/InP DH LED and the light output versus current characteristics

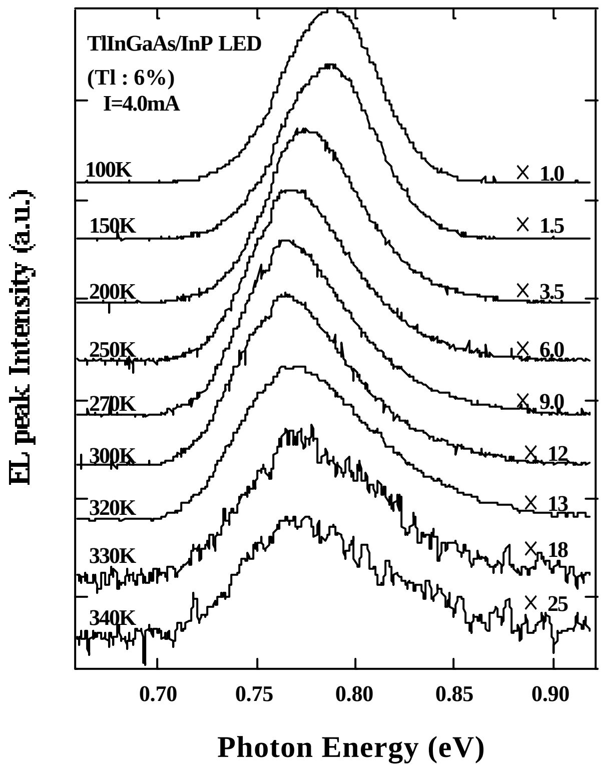

Fig.2 EL spectra (current: 4.0mA) for the TlInGaAs/InP DH LED at 100-340K

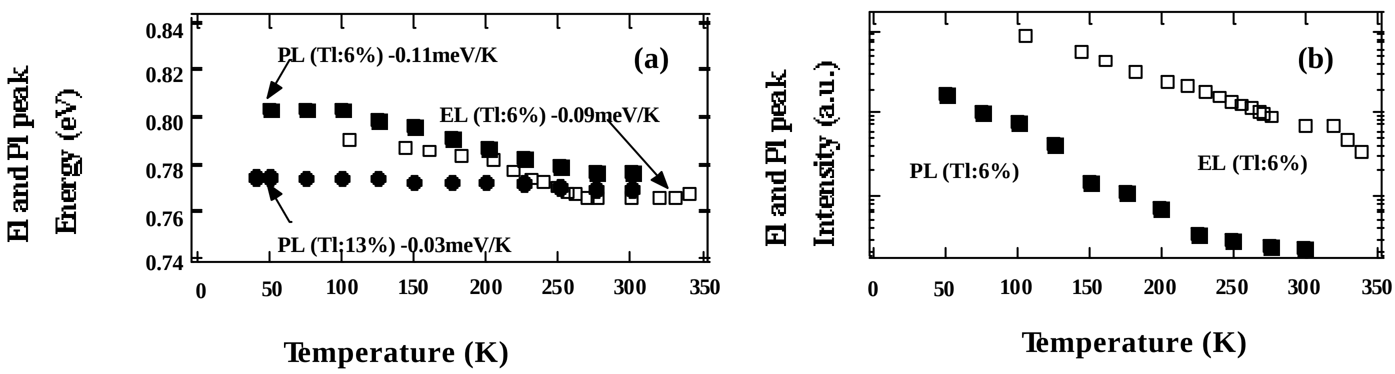

Fig.3 Temperature variation of (a) EL and PL peak energies, and (b) EL and PL peak intensities.