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The effect of distribute Bragg reflector in device temperature of AlGaInP light-emitting diode

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1. Introduction

High-brightness Light emitting diodes (LEDs) are becoming popular in general lighting source due to the reliability and the conveniently which are much smaller than light bulbs. Since LED belongs to spontaneous emission, half of light emitting toward the substrate will be useless because of the absorption especially in AlGaInP/GaAs LED. Distributed Bragg reflector (DBR) has been considering as an effective way to reduce substrate absorption [1] and is widely utilized in modern LED structure. However, such period structure might lead to high thermal resistance amount entire devices.

Our previous research found that while measuring AlGaInP LED spectra, we are able to find two peaks signals from 500nm to 1000nm. These peaks are confirmed as the electroluminescence (EL) from multi quantum well (MQW) and the photoluminescence (PL) from GaAs substrate [2]. Therefore, by measuring the spectra emission from MQW and GaAs substrate, we were able to observe temperature difference across DBR layers at the same time while using peak wavelength shift method and self-excited PL method.

2. Experiment

The sample studied here contains the n-type GaAs substrate, an $Al_xGa_{1-x}As/Al_yGa_{1-y}As$ (DBR), an AlGaInP n-cladding layer, an AlGaInP multi-quantum well, an AlGaInP p-cladding layer and a GaP current spreading layer. The LED sample was mounted on an aluminum board and place in the vacuum chamber.

As fig.1 show, the spectra of AlGaInP LED were measured under 1mA and 20mA operation at various temperatures. PL peaks at 1mA were too weak that cannot ex tract from system noise. But in self-excited PL method, we are able to use Vashini equation to examine the temperature of GaAs substrate [3]. Fig.2 (a) and (b) presented the peak shift characteristic of both MQW EL and GaAs PL. The peak wavelength for both 1mA and 20mA show nonlinear shift at low ambient temperature in fig.2 (a). So it became difficult to calibrate the junction temperature for 20mA from the slope of temperature-dependent peak wavelength shift at 1mA. In this case, 1mA peak wavelength shift were calibrated by polynomial function, and then junction temperatures at 20mA were obtained by corresponding to the same peak position with polynomial function.

Fig.2 (b) shows the peak energy shift of GaAs PL. The substrate temperature was obtained from Vashini equation.

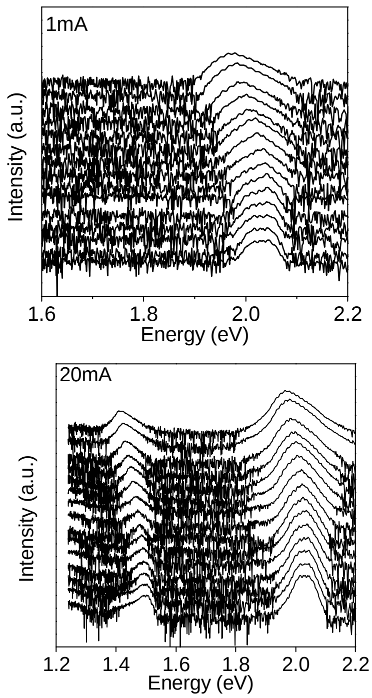

Fig. 1 Temperature-dependent spectra of the chip under 1mA and 20mA operation. From bottom to top, the temperature curves are 64K, 70K, 74K, 85K, 90K, 109K, 125K, 149K, 163K, 183K, 206K, 234K, 255K, 272K, and 304K.

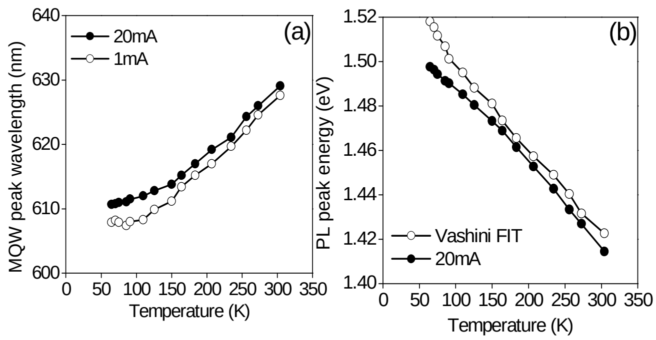

Fig. 2 (a) Quantum well EL signal at various temperatures. Solid and circle points indicate the peak positions under 20mA and 1mA operated. (b) GaAs substrate PL signals at various temperatures. Solid points indicate the peak positions at 20mA and circle points are obtained from the Vashini equation, $E_g(T) = 1.512 - 0.00051\, T^2/(T+190)$.

The coefficient α, β and $E_g(0)$ used here are 0.00051, 190 and 1.512 [3,4]

The junction temperature and substrate temperature were plotted in fig.3. Both temperatures were in good agreement above 150K but show inconsistent characteristic below 150K; meanwhile, the temperature difference between junction and substrate is getting larger when the ambient temperature is getting lower. This phenomenon is probably due to the increasing dispersion of phonon in DBR layers [5]. Therefore, DBR layers show low thermal conductivity below 150K. As show in fig.4, while the input power is increasing when ambient temperature is decreasing, due to the forward voltage increasing, the junction temperature exhibited just like the input power but substrate temperature exhibited only little affected.

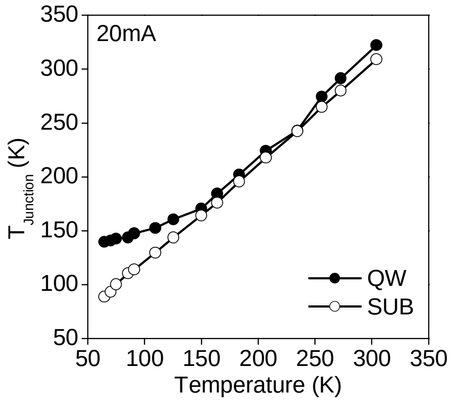

Fig. 3 Junction temperature at various temperatures under 20mA operated.

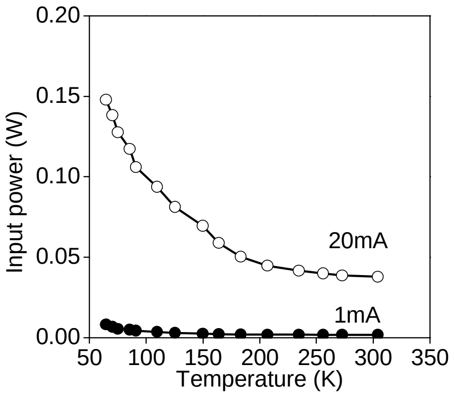

Fig. 4 Input powers at various temperatures under 20mA and 1mA operated.

3. Conclusions

This work presents the temperature difference above and below the DBR in AlGaInP LED. The increasing junction temperature expressed identically as the input power. By observing the peak shift from MQW EL and GaAs PL, the temperature difference shows that DBR plays an important role at low temperature measurement.

Acknowledgements

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