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Thermal Resistance of 1.3 μm AlGaInAs/InP MQW Ridge Lasers

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1. Introduction

Thermal resistance is one of the most important parameters for CW characteristics in junction laser diodes. It is very important not only for the temperature characteristics but also for the device reliability, since a large temperature increase of the CW lasers may accelerate the degradation rate.

The most straightforward way to reduce the thermal resistance is to adopt junction-down mounting. However, there have been few reports on the application of the junction-down mounting to ridge waveguide lasers, which is becoming more popular recently because of its simplicity in the fabrication process.

In this work, we have fabricated 1.3-µm AlGaInAs/InP multi-quantum-well (MQW) ridge lasers with junction-down mounting, and the thermal resistance and maximum CW temperature have been compared with those for junction-up mounting. The thermal resistance was found to be 40 % smaller and the maximum temperature was improved by 20 °C in the junction-down mounting. As a result, the CW lasing operation have been achieved up to 185 °C for the lasers with junction-down mounting, which is one of the highest temperature ever reported for InP-based long wavelength lasers.

2. Laser structure

Figure 1 shows a schematic of the fabricated AlGaInAs/InP MQW ridge laser. The laser structure was grown on as n-InP substrate by MOVPE at 670°C. The MQW active layer consists of seven 0.5% compressively-strained AlGaInAs wells (d = 6 nm) and lattice-matched AlGaInAs barriers (d = 10 nm). These AlGaInAs materials have been recently demonstrated to provide better temperature characteristics than GaInAsP systems [1]-[2], because of a larger conduction-band offset resulting in a stronger electron confinement. The fabricated structure was processed into Fabry-Perot ridge lasers with a neck width of 2-µm. The reverse-mesa shape was formed by the combination of dry and selectively wet etching and buried by polyimide. The fabricated devices were cleaved into 350-µm-long cavity and mounted on Si heatsinks with junction-up and -down configuration. Lasers with two different mirror reflectivities were prepared: both facets as-cleaved (28%-28%) and highly reflective coated (60%-95%).

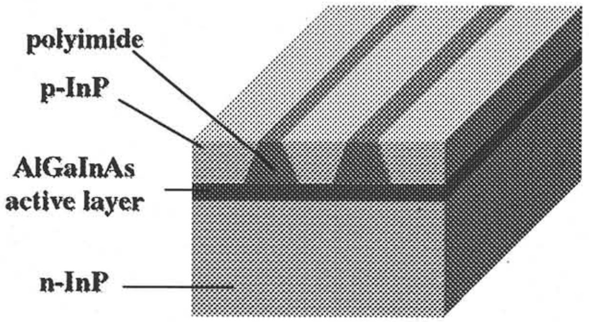


Figure 1 The schematic drawing of 1.3-µm AlGaInAs/InP MQW ridge waveguide laser.

3. Device performance

A. Thermal resistance

We have used Paoli's method [3] to measure the thermal resistance of the ridge lasers. The thermal resistance R_{th} is defined by

$$R_{th} = \frac{\Delta T}{P_{in}} [K/W]$$

where ΔT is temperature increase in the active layer and P_{in} is internally consumed electric power. ΔT is determined from the difference in the wavelength of one particular Fabry-Perot mode between pulsed and CW operation. P_{in} is evaluated by subtracting the total light output power from the input electrical power: $P_{in} = I \cdot V - (P_f + P_r)$, where I is the injected current, V is the applied voltage, and P_f and P_r is the light output from the front and rear facet, respectively. The two lines in Fig. 2 show the experimental results of thermal resistance at a heatsink temperature of 40°C for junction-up and junction-down mounting, respectively.

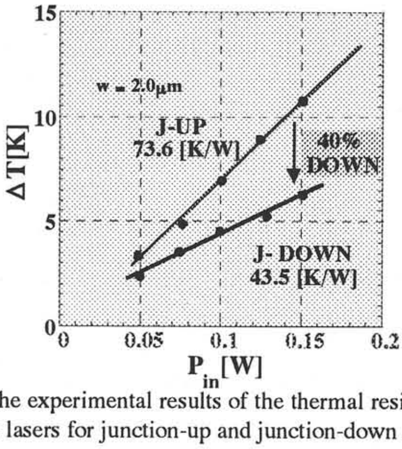


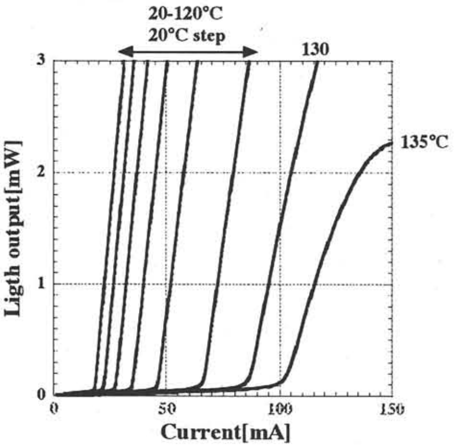
Figure 2 The experimental results of the thermal resistance of ridge waveguide lasers for junction-up and junction-down configuration.

Thermal resistance was found to be 73.6 K/W for junction-up and 43.5 K/W for junction-down, resulting in about 40% reduction of the thermal resistance for junction-down mounting. This result is consistent with the theoretical estimation obtained by Joyce and Dixon method. [4]

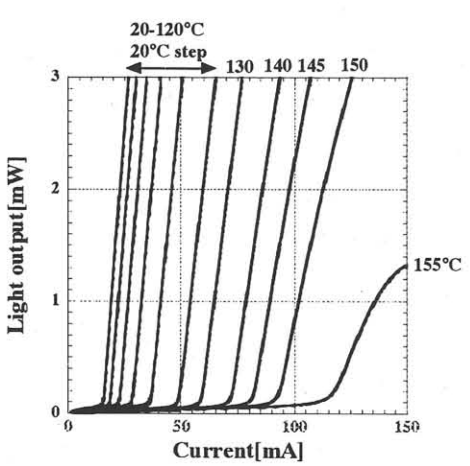
B. Maximum temperature

The maximum CW operating temperature (T_{max}) is one of the useful indicators representing the temperature characteristics of the lasers as well as the characteristic temperature T_0. We have also measured T_{max} of the ridge lasers with junction-down mounting and compared with that for junction-up mounting.

Figure 3 (a) and (b) show the experimental results of the maximum CW temperatures of 350-μm-long ridge waveguide lasers with (a) junction-up and (b) junction-down configuration. The both facets were as-cleaved (28%-28%) in these lasers. The maximum temperature was measured to be 135 °C for junction-up mounting, and 155 °C for junction-down. T_{max} was improved by 20 °C by adopting the junction-down mounting due to the reduction of the thermal resistance.



(a) Junction-up configuration



(b) Junction-down configuration

Figure 3 The experimental results of the maximum CW temperatures of 350-μm-long waveguide lasers with (a) junction-up and (b) junction-down configuration. Both facets are as-cleaved (28%-28%) in these lasers.

We also measured T_{max} of HR-coated lasers (60%-95%) with junction-down mounting. Figure 4 shows the experimental result of the maximum temperature. We have achieved T_{max} = 185°C, which is one of the highest CW operating temperatures reported in the InP-based long wavelength lasers.

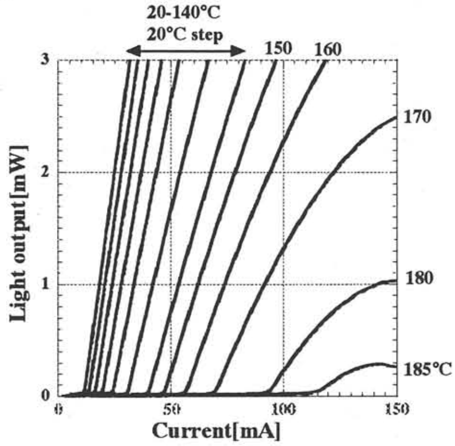


Figure 4 The experimental results of the maximum CW temperature of 350-μm-long waveguide lasers with junction-down configuration. Both facets were highly reflective-coated in this laser (60%- 95%).

4.Conclusion

In this work, we have fabricated 1.3-μm AlGaInAs/InP MQW ridge waveguide lasers and measured thermal resistance and the maximum CW temperature for both junction-up and junction-down configuration. As a result, we have found that the R_{th} is 73.6 K/W and T_{max} is 135 °C for junction-up and R_{th} is 43.5 K/W and T_{max} is 155 °C for junction-down mounting, respectively. And we also have achieved CW T_{max} as high as 185°C with 350-μm-long HR-coated lasers, which is one of the highest CW temperature reported so far for InP-based long wavelength lasers.

Reference

1) K. Takemasa, T. Munakata, M. Kobayashi, H. Wada, and T. Kamijoh, "High-temperature operation of 1.3-μm AlGaInAs strained multiple quantum well lasers," Electron. Lett., vol.34, pp. 1231-1233, 1998.

2) C. E. Zah, R. Bhat, and T. P. Lee, "High temperature operation of AlGaInAs/InP lasers, " Conference proceeding of 7th Inter. Conf. on InP and Related Materials, paper WA-1-1, pp.14-17, 1998.

3) T. L. Paoli, "A New Technique for Measuring the Thermal Impedance of Junction Laser," IEEE J.Q.E., vol. QE-11, No.7, pp.498 - 503, 1975.

4) W. B. Joyce and R. W. Dixon, "Thermal resistance of heterostructure lasers," J. A. P., vol.46, No.2, pp. 855-862, 1975.