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# High Temperature Operation of Index-Guided AlGaInP Semiconductor Lasers

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Temperature characteristics are important for AlGaInP laser applications. Although much effort has been undertaken to achieve higher temperature operation of AlGaInP lasers, improvements up to that of AlGaAs lasers have yet to be found. In this paper, the improvement of temperature characteristics is investigated in ridge-stripe index-guided lasers with a GaInP active layer. Reduction of the threshold current density divided by active layer thickness is important for higher temperature operation because it allows the injected carrier density at a threshold lower. Therefore, optimizing the active layer thickness, which determines carrier confinement, and use of reflective facet coating, which effectively reduces threshold current density, are examined.

The ridge-stripe lasers are fabricated by three-step crystal growth. The p-type and n-type cladding layers with an Al composition of 0.7 have a hole concentration of $4\sim5\times10^{17}$ $cm^{-3}$ and electron concentration of $9\times10^{17}\sim1\times10^{18}$ $cm^{-3}$. Heterobarrier height between the active layer and the cladding layers is estimated greater 400 meV by measuring the photoluminescence spectra of the cladding layers. Cavity lengths are 250 $\mu$m and Si submounts are used as the heatsink material. Lasing wavelengths range from 670 to 680 nm.

Characteristic temperature $T_0$ and the maximum lasing temperature Tmax are measured with respect to the active layer thickness da under CW operation, as shown in Fig. 1 and Fig. 2, respectively. Experimental data are obtained in both uncoated and reflective coated (front facet reflectivity of 30% and rear of 90%) samples. Threshold currents of 27 to 36 mA are obtained in the uncoated samples. Higher temperature operation is achieved in the lasers with a da of around 60 nm. Reduction of threshold current density by 15% is achieved with the reflective coating. Higher temperature operation in the reflective coated samples is obtained due to the lower threshold current density compared with the uncoated samples. Both $T_0$ and Tmax decrease as da becomes less than approximately 60 nm. These decreases are attributed to the decrease of carrier confinement and the increase of electron overflow. Therefore, to achieve higher temperature operation in the lasers with a da of less than 60 nm, it is necessary to increase the heterobarrier height by increasing Al composition of the cladding layers. It is also effective to suppress temperature increases in the active layer. Thermal resistivity of the lasers on the Si submount is evaluated as about 30 K/W by measuring output power decrease when the lasers are driven under pulsed operation. Temperature rise in the active layer under CW operation of 5 mW is estimated of 3 to 5 degrees. Heatsink materials with larger thermal conductivity are suitable for further high temperature operation. Fig. 3 shows the temperature dependence of L-I characteristics in the reflective coated sample with a da of 61 nm. The lasing wavelength is 682 nm at 5 mW. A maximum lasing temperature of 130℃ is attained. This value is the highest operating temperature in AlGaInP lasers. Life test is performed at a heat block temperature of 70℃ and an automatically controlled output power of 5 mW. No remarkable deterioration is observed after more than 1300 hours, as shown in Fig. 4. As a result, the life test of AlGaInP lasers under higher temperature CW operation is successful.

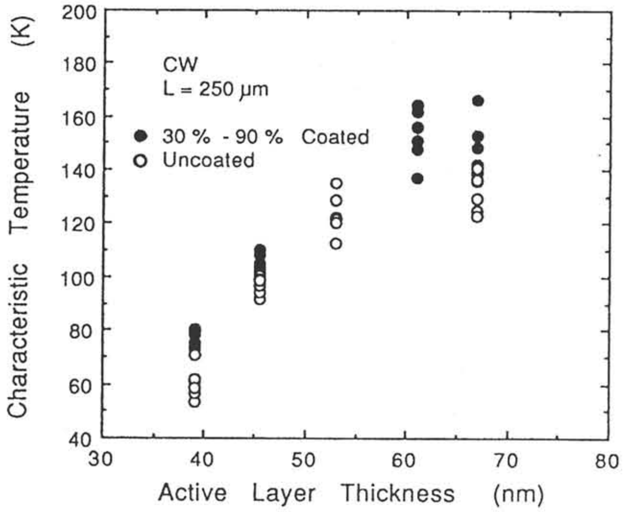


Fig. 1 Characteristic Temperature $T_0$ of index-guided AlGaInP lasers with respect to the active layer thickness

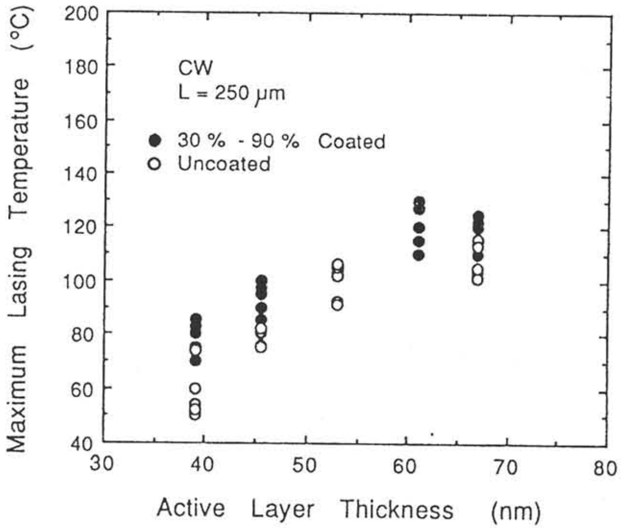


Fig. 2 Maximum lasing Temperature Tmax of index-guided AlGaInP lasers with respect to the active layer thickness

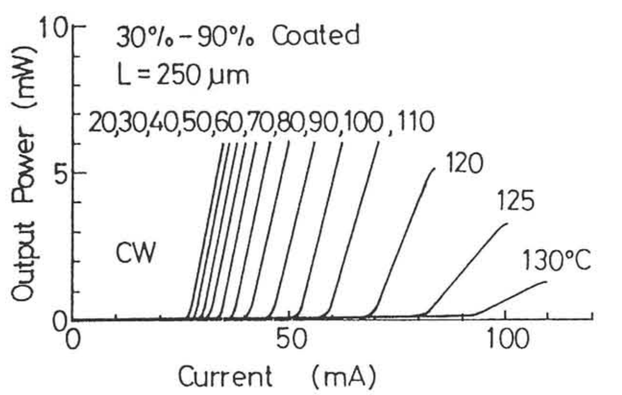


Fig. 3 Temperature dependence of light output power vs. injected current of an AlGaInP laser with the reflective coatings on a Si submount

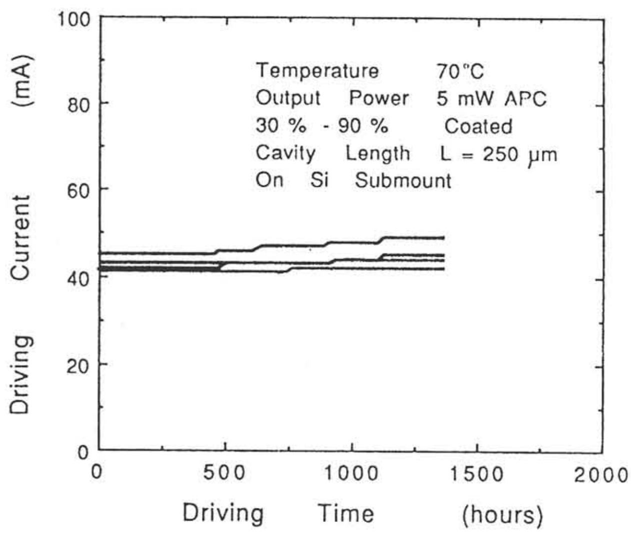


Fig. 4 Life test results of AlGaInP lasers with the reflective coatings at a heat block temperature of 70 ℃ and 5 mW APC