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${\rm B}-5-2$ High temperature single-mode cw operation with a TJS laser using a semi-insulating GaAs substrate

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1. Introduction

Generally, the lasers have been mounted upside down, and skilful techniques and careful handlings are required in the fabrication. To avoid such a nuisance state, a new laser with a simple structure is developed using the principle structure of the TJS laser^{1),2)} and a semi-insulating GaAs substrate. The laser discussed here is the first laser mounted with epitaxial layers up that can operate continuously in a single-mode even over 110°C. The new laser with such excellent characteristics makes the application to various optical device systems much easier. Further, the simple structure and the electrical isolation by the semi-insulating substrate will be suitable for the monolithic integration of optical circuits.

2. Devise Structure and Fabrication

The schematic diagram of the new geometry TJS laser and the parameters of each growth layer are shown in Fig. 1 and Table 1, respectively. Only four layers are successively grown on a semi-insulating GaAs substrate. The last n⁺GaAs layer introduced to obtain good ohmic contacts is isolated by mesa-etching

at the p-n junction. The new laser is mounted with epitaxial layers up and the heat sink is attached to the substrate.

3. Results

Figure 2 shows the radiant flux - current characteristics of the new laser from -20°C to 110°C during cw operation. The radiant flux increases lineally with increasing the input current in all range of the operating temperature. The differential external quantum efficiency is about 50 % at 25°C in a 250 μ m long cavity. The minimum value of the threshold current obtained at 25°C so far was 15 mA in cw operation. The muximum peak power of 15 mW corresponding to the power density of 3 x 10⁶ W/cm² has been obtained at 25°C, which is comparable to that of DH lasers.³⁾



Fig. 1. New TJS laser structure

Table	1.	Parameters of			
		growth	layers		

layer	thick- ness(µm)	A1 content	carrier -3)	dopant
n-GaAs	1		2×10 ¹⁸	Te
n-AlGaAs	1.5	0.45	2x1017	Te
n-GaAs	0.3		2×1018	Te
undoped- AlGaAs	3	0.45	1×10 ¹⁶	

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The temperature dependence of the relative change of the threshold current is The threshold current is proportional to T³ in a wide range shown in Fig. 3. No rapid increase of the threshold current is of the ambient temperature.

observed to a temperature as high as 110°C. It is considered to suggest that an area of the (Al,Ga)As p-n junctions outside the active region is very narrow in the new structure, so the shunt current is mostly eliminated and the current is effectively concentrated to the active region.

Figure 4 shows the typical lasing spectrum of the laser at 100°C. The peak radiation wavelength is about 918 nm at It 118 mA. exhibits the single longitudinal mode The active region is oscillation. "homogeneous" like because of the small volume and the high carrier density of the active region. The single longitudinal mode oscillation has been well explained by using the multi-mode rate equations assuming homogeneous broadening laser. 4) The fundamental transverse mode is also dominant in both directions. In these lasers, no change of the modes has been observed to a few times of the threshold. The lasers heat-sinked through the semiinsulating substrate are still operating after 3,000 hours cw aging at 20°C with no obvious degradation of the characteristics.

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