In order to improve the brightness, efficiency, and reliability of projectors, it is desirable to use laser diodes (LDs) as the light source. Recently, Mitsubishi Electric announced mass production of a red LD that can emit the world's highest output of 2.5 W under pulse condition with wavelength of 638 nm.\(^1\) The LD is equipped with our original high-output technologies and assembled on a 9 mm diameter TO CAN, offering brilliant and deep red color.

1. **Introduction**

While high-pressure mercury lamps have been widely used as light sources for projectors so far, LDs have advantages such as higher efficiency, wider color gamut, highly-reliable operation, low environment impact, and so on. Projectors with blue LDs and phosphors have already started to penetrate into the market.

Red LDs, on the other hand, have not been used for the light source because of insufficient optical output per device. There are two causes to prevent the red LD from high power operation. One is the catastrophic optical degradation (COD) due to light absorption at the front facet of the LD. Another is the light output saturation due to the temperature rise in the active layer.

An effective method of preventing COD is to reduce the light density at the facet of the laser diode. In this LD, the total width of the light emitting region was increased from the previous value of 40 μm to 180 μm. The emitting region was divided into three regions, each with a width of 60 μm. Dividing the emitting region reduces the heat generation density, allowing for the active layer temperature to be kept low.

Figure 1 shows the schematic structure of the LD. The LD equipped with our original window-mirror structure for an additional measure against COD. Zinc was selectively introduced into the facet mirror region as an impurity and disordering the active laser was performed by annealing.

In addition, in order to lower the active layer temperature, the newly developed φ9 mm TO-CAN was used for the package, contrary to the previous LD that is assembled on φ5.6 mm open TO. The large φ9 mm TO reduces both the thermal resistance of the package and the thermal contact resistance between the package and the LD holder.

2. **Device Characteristics**

The light output power versus injection current characteristics of the previous and this product are shown in Fig. 2 (a) and (b), respectively. The drive condition was pulse operation with a duty cycle of 30% and frequency of 120 Hz; the temperature indicated in the figure was the temperature at the bottom surface of the package (case temperature).

The previous product showed the output power saturation at the high temperature and/or high output power regions. On the other hand, the newly developed are showed excellent characteristics exceeding 2.5 W at the case temperature between 25 and 45°C.

Operation current at output power of 2.5 W, case temperature of 25°C and 45°C were 2.71 A and 3.41 A, respectively. The corresponding operation voltages were 2.26 V and 2.33 V, respectively. The slope efficiency at 25°C was 1.20 W/A.

The beam divergence angles along the slow and fast axes with the peak power of 2.54 W at the case temperature of 25°C were 7.3° and 73.6°, respectively. The values were the angles at the position where the light intensity was 1/e² of the maximum value.

The peak wavelength was 638.6 nm, and the full width at half maximum of the spectrum was approximately 1.6 nm.

3. **Reliability**

Figure 3 shows the aging test results of the product. The aging condition was auto current control mode with the initial power of 3.4 W under the CW operating condition. The case temperature was set to be equivalent to that at the ambient temperature of 25°C.
during pulse operation with the duty of 30%. Considering that the degradation rate due to COD is proportional to the power of 3.2 of the optical output power, the acceleration factor of this aging test was 2.68 (=3.4 W/2.5 W)^{3.2}. Based on this factor, the aging duration of 5,500 hours at 3.4 W is equal to 49,000 hours at 2.5 W with the duty of 30%, indicating that this LD has high reliability.

4. Summary

The high power red LD for the light source of the projector was newly developed and launched. The LD has the maximum power rating of 2.5 W under the pulse operation, which is the world’s highest output record for a CAN package type red LD in the 638 nm band to the best of our knowledge.

Mitsubishi Electric is developing the LDs with even higher power for pulse operation and also the LDs for CW operation to meet the demand for high-brightness projectors.