B—4—7 Reliability of GaAlAs Visible-Light-Emitting MCSP Lasers

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Considerable interest has been focused on GaAlAs visible diode lasers operating at wavelengths around 780nm as light sources for digital audio disk and optical video disk playback systems. In these applications, the greatest concern is laser reliability. This paper looks at the influence on laser reliability of active layer thickness and the p-type dopant for the cladding layer. Results from an accelerated life test for 74 lasers are also presented.

Lasers with a modified channeled substrate planar (MCSP) structure[1)] were used in this experiment. Lasers with SiO_2 half-wave facet coatings were bonded with the p-side down on a submount with PbSn solder. The cavity length of the laser was 300μm.

Lasers from more than 30 wafers, which had active layer thicknesses of 0.025-0.06μm, were subjected to a 24-hr burn-in period at $50^{o}C$ under constant current operation. This was done in order to investigate the influence of the active layer thickness on laser life times. The initial light output power was 3mW/facet. The ratio of the number of lasers which maintained 90% or more of initial light output power after burn-in to all that of lasers examined is plotted for each wafer as a function of the active layer thickness in Fig.1.

Most lasers with an active layer thickness of less than 0.04μm degraded very rapidly. It was found that an active layer thickness of 0.04μm corresponds to the one where an abrupt increase in J_{th}/d (the threshold current density divided by the active layer thickness) happened. The abrupt J_{th}/d increase could be explained as being due to the decrease in the optical confinement factor that resulted from a decrease of d. Moreover, lasers in which J_{th} value was artificially increased by quarter-wave facet coatings were found to degrade very rapidly. These results show that carrier density in the active layer at the lasing threshold strongly affects laser lives. For lasers with a relatively thin active layer, control of the active layer thickness is important for obtaining highly reliable and reproduciable lasers.

Germanium is an attractive element as a p-type dopant for a GaAlAs cladding layer with a relatively small AlAs mole fraction. This is because of its low vapor pressure and small diffusivity.[2)] Lasers with a Ge-doped cladding layer were fabricated, and their reliability was compared with that for usual lasers having a Zn-doped cladding layer. Results of aging test under a constant light output power of 5mW/facet at 70°C are shown in Fig.2. Threshold currents for these lasers were 43-60mA at a room temperature. The difference in the driving currents betweeen these lasers is mainly caused by the temperature dependence of the threshold current. Lasers with a Ge-doped cladding layer degraded faster than ones with a Zn-doped cladding layer. Degradation proceeded faster for lasers having greater Ge doping. These results show that Zn is superior to Ge as a p-type dopant for $Ga_{1-x}Al_xAs$ cladding layer with x≳0.45.

An accelerated life test was performed for 74 lasers from 8 wafers,in which the active layer thickness was controlled and zinc concentration of the p-type cladding layer was optimized, under a constant light output power of 5mW/facet at 70°C. Although two lasers failed at 890hr and 1457hr, respectively, the other lasers have operated stably for more than 2000hr. The distribution of the average degradation rate during 2000hr operation is shown in Fig.3. The degradation rate for most lasers is less than 5×10^{-3}mA/hour. This proved that the MCSP laser is a highly reliable laser.

References

1) T.Kuroda, T.Kajimura, S.Yamashita, J.Umeda, K.Aiki, paper presented at the Autumn Meet. Japan Society of Applied Physics, Fukui, p171 (1981)
2) W.Nijman, W.J.Leswin, and P.Thijs, IEEE J.of Quantum Electron., QE-17, 767 (1981)

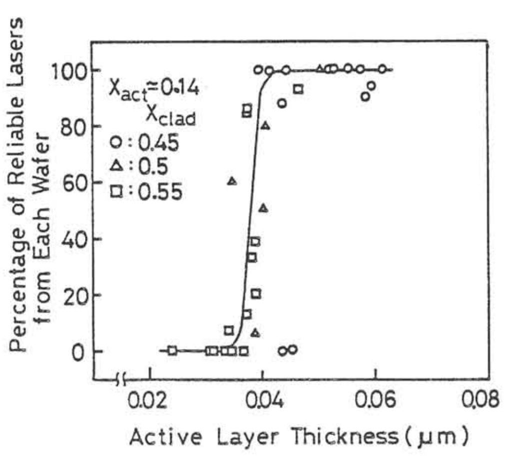

Fig.1 Relationship between active layer thickness and percentage of reliable lasers from each wafer. More than 10 lasers from each wafer were subjected to the life test. Zinc and tellurium were used as p- and n-type dopant of the cladding layers, respectively, in this experiment.

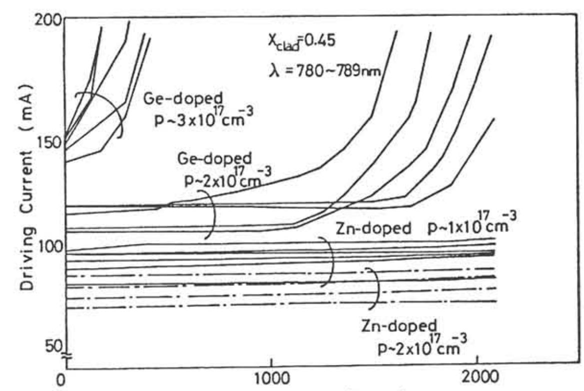

Fig.2 Aging results for lasers with Ge- and Zn-doped cladding layers.

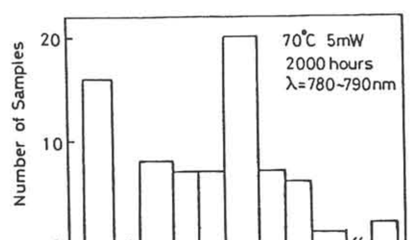

Fig.3 Distribution of average degradation rate during 2000hr operation for 74 MCSP lasers from 8 wafers.