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Inverted Inner Stripe Laser with a p-GaAs Buffer Layer Grown by MOCVD

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820nm high power laser (I^2SPB laser) which can oscillate at 50mW up to 100°C has been developed by employing MOCVD technique. Typical characteristic temperature To is 160K. The astigmatic distance is less than 6μm in the power range between 1mW and 30mW, and S/N ratio (f=20kHz, BW=300Hz) is larger than 65dB. MTTF at 60°C, 30mW is estimated to be longer than 20000 hours. The I^2SPB laser is a promising light source for ODD (optical disk drive) systems.

Recently, optical disk drive (ODD) systems are becoming promising media for data storage, because they have large storage capacity, short access time and so on. It is necessary for light sources of ODD systems to have characteristics such as not only high light output power but also shorter wavelength, small wave front distortion (equal to small astigmatic distance[1]), low optical noise and high reliability. It is also necessary for the sources to have uniform characteristics and low price to reduce the total cost of ODD systems. As the most suitable light sources for ODD systems, high power AlGaAs laser diodes of 780∿820nm band, which satisfy the above characteristics, are strongly required.

The maximum light output power of AlGaAs laser is limited by the degradation which originates from light absorption at the mirror facets.[2],[3] Several methods are proposed to reduce the light absorption.[4],[5],[6] The most popular method is thinning the active layer to reduce the optical power density. It is easy for MOCVD technique to grow thin epitaxial layers.[7] Therefore, MOCVD is thought to be a suitable method for high power lasers with a thin active layer. However, there is an optimum thickness of the active layer. If the active layer is thinner than this value, it increases the threshold current and degrades the characteristic temperature To.[8] As a result, the reliability will be reduced.

We have developed a new high power laser diode grown by MOCVD. The laser structure is schematically illustrated in Fig.1. This device is fabricated by a two step MOCVD technique. The difference of Al mole fraction between the active layer and the cladding layer is 0.35. To realize high power oper-

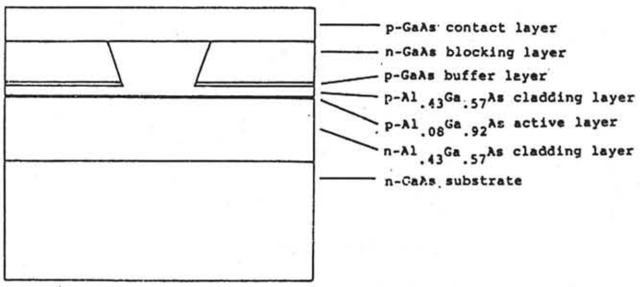

Fig.1 Schematic of the I^2SPB Laser

ation at high temperature, the thickness of the active layer is designed to be 0.05µm. The structure is characterized by the following two epitaxial layers. One is p-GaAs buffer layer (0.1µm) and the other is n-GaAs current blocking layer (1.0µm). By this structure, excellent current blocking effect can be maintained up to high temperature such as 100°C. As a result, high value of To has been realized at high temperature. Remarkable high power operation at high temperature also has been achieved. We call this device I^2SPB laser (Inverted Inner Stripe Laser with a p-GaAs Buffer Layer). The cavity length is 400µm, and the laser chip is mounted on a heat sink with p side down. The low reflectivity such as a few% of front facet is usefull for high power operation. But it causes external cavity mode hopping, and degrades optical signal to noise ratio.(9) Therefore, the reflectivity of the front and rear facets is designed to be 12% and 60%, respectively.

Temperature dependence of P-I (light output power vs operation current) curves is shown in Fig.2. At 25°C, the threshold current is about 50mA, and the external slope efficiency is about 0.45W/A. There is no kink up to 55mW. Lasing wavelength is 825nm at 30mW CW, 25°C. Temperature dependences of P-I curves are very small at the case temperature below 80°C. To is about 160K below 80°C, and about 100K above 80°C. Remarkable high power operation of 50mW CW at the case temperature of 100°C has been realized. This superior temperature characteristics are mainly due to both the leakage current reduction at high temperature obtained by p-GaAs buffer layer and improved thermal resistance with long cavity (400µm).

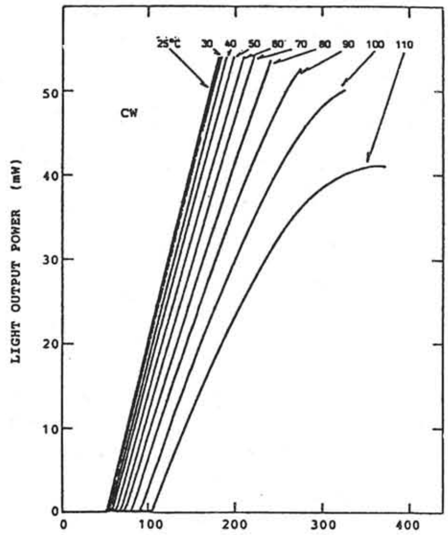

Fig.2 Temperature Dependence of P-I Characteristics

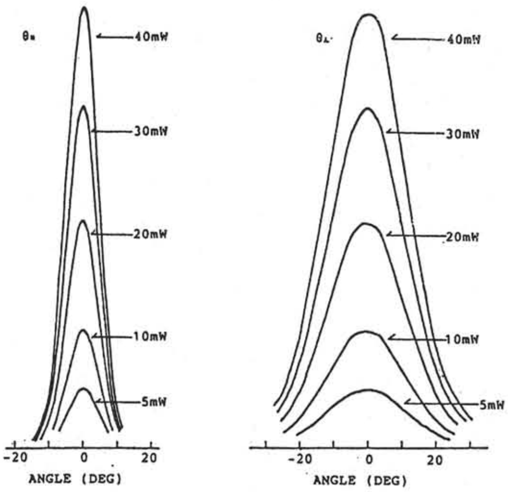

Fig.3 Light Output Power Dependence of Far Field Pattern

Fig.3 shows the light output power dependence of far field pattern (FFP). The full width at a half maximum (FWHM) parallel to the junction plane ($\theta_{\parallel}$) is about 11°, and FWHM perpendicular to the junction plane ($\theta_{\perp}$) is about 26°. No change in the peak position and the shape of FFP is observed up to 40mW. This means that the stable fundamental transverse mode is maintained.

Typical measurement result of the astigmatic distance at 3mW is shown in Fig. 4. The laser beam is measured by the optical system with magnification of 600. The spot sizes parallel to the junction plane and

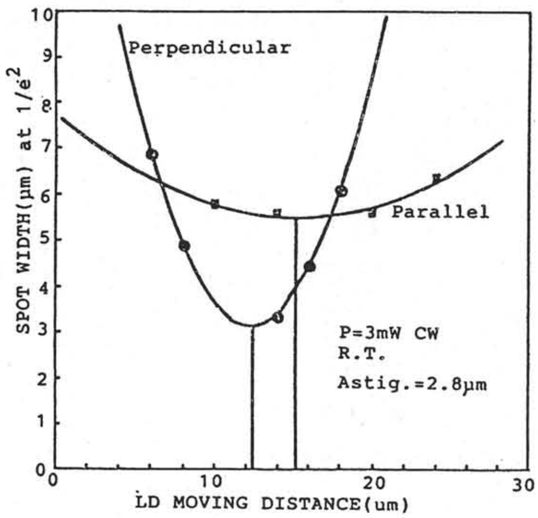

Fig.4 Measurement Result of Astigmatic Distance

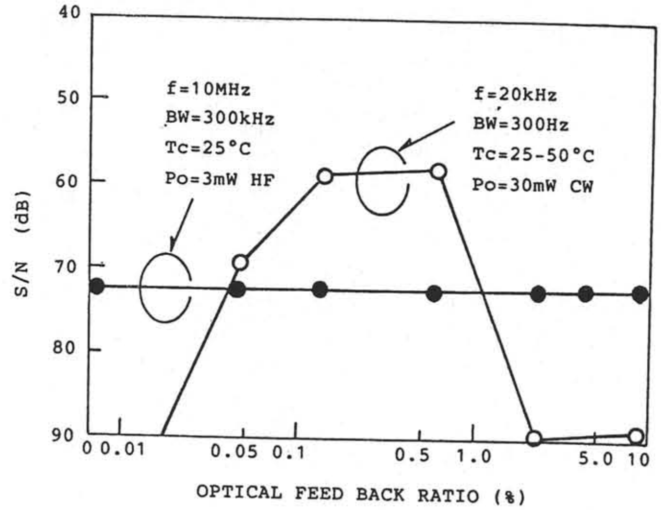

Fig.5 Optical S/N Ratio vs Optical Feedback Ratio

those perpendicular to the junction plane are plotted as a function of laser chip position. The astigmatic distance of this device is 2.8μm. The astigmatic distance is almost constant in the power range between 1mW and 30mW. The measurement results for 50 chips from one wafer are as follows; max. =5.8μm, min.=0.0μm, ave.=2.6μm, and σ=1.4μm. In the real ODD systems, the required value of the astigmatic distance is thought to be less than 6μm. The astigmatic distances of the I^2SPB lasers are less than this value. This means that the I^2SPB lasers are suitable sources for ODD systems.

The optical signal to noise ratio S/N is shown in Fig.5 as a function of the optical feedback ratio. In this figure, both data under high power (Po=30mW; writing or erasing) and low power (Po=3mW; reading) conditions are shown. In the case of high power condition (circles), the central frequency (f) is 20kHz and band width (BW) is 300Hz. Though a "bump", which is due to mode hopping noise induced by the optical feedback, is observed in the optical feedback ratio between 0.05% and 1%, the S/N ratio is better than 65dB in the range from 1% to 10%. In the real ODD systems, typical optical feedback is about 1 to 10% and S/N value is required to be better than 65dB. In the case of low power condition (dotts), f=10MHz and BW=300kHz. In this case, high frequency (∿750MHz) current is superimposed on the laser current to reduce the mode hopping noise. As a result, S/N value is improved to be about 73dB, which is better than the required level, in the range from 1 to 10%. These results show that the I^2SPB lasers are suitable sources for ODD (writing,erasing,and reading) systems.

Fig.6 shows the distributions of $\theta_{\parallel}$ and $\theta_{\perp}$ for 130 samples which are fabricated from one wafer. The average value of $\theta_{\parallel}$ and $\theta_{\perp}$ is 11.0° and 26.5°, respectively. The standard deviation is 0.4° and 0.5°, respectively. This means that a remarkabe productivity has been realized by this structure grown by MOCVD technique.

Fig.7 shows CW aging test results under a constant light output power of 30mW at 60°C. All devices are operating stably for more than 1600 hours. The mean time to failure (MTTF) at 60°C, 30mW CW is estimated to be longer than 20000 hours.

In conclusion, we have demonstrated the high power operation of the I^2SPB laser at high case temperature. 50mW CW operation at

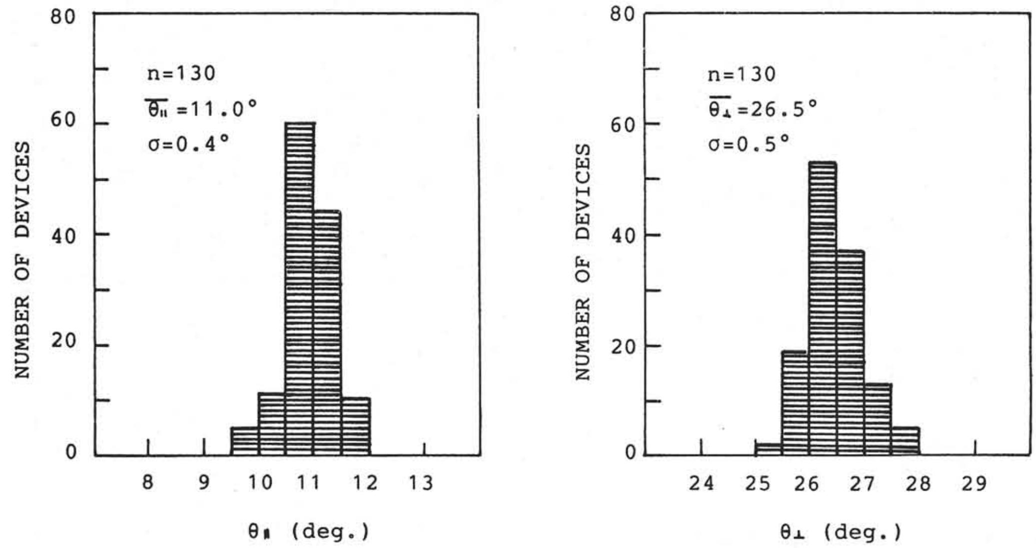

Fig.6 Distributions of $\theta_{\parallel}$ and $\theta_{\perp}$

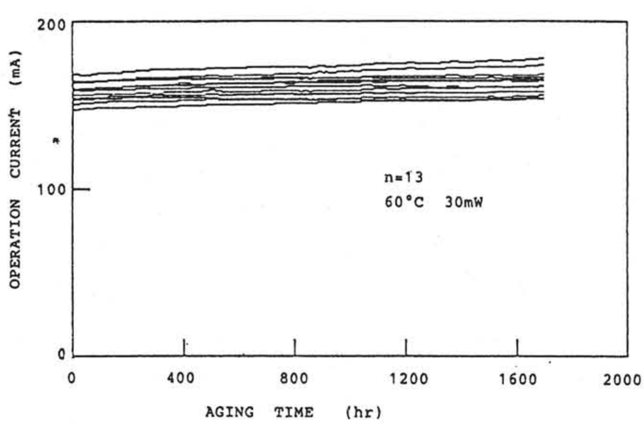

Fig.7 CW Aging Test Results of I^2SPB Lasers at 60°C, 30mW

100°C has been realized by this structure. The astigmatic distance is smallerthan 6μm, and optical S/N ratio is larger than 65dB at f=20kHz, BW=300Hz, and Po=30mW CW. Uniformity of the characteristics such as $\theta_{\parallel}$ and $\theta_{\perp}$ etc is extremely excellent. MTTF at 60°C, 30mW is estimated to be longer than 20000 hours.

The I^2SPB laser is suitable light source for ODD system because of its high light output power, small astigmatic distance, high optical S/N ratio, long life time, and so on.

References

(1) K.Tatsuno et al : Appl. Opt. 20(1981)3520
(2) H.Yonezu et al : J. Appl. Phys. 50(1979) 5150
(3) C.H.Henry et al : ibid 50(1979)3721
(4) T.Ohtoshi et al : J. Appl.Phys. 56(1984) 2491
(5) K.Hamada et al : IEEE J. Quantum Electron. QE-21(1985)623
(6) K.Endo et al : Electron. Lett. 20(1984) 728
(7) W.T.Tsang et al : Appl. Phys. Lett. 38 (1981)204
(8) N.Chinone et al : Appl. Opt. 17(1978)311
(9) K.Yamashita et al : Proceedings of SPIE 610(1986)152