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Realization of Highly Reliable High-Power Operation of Single-Stripe AlGaAs Lasers by the Formation of Window Grown on Facets

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High-power single-stripe AlGaAs lasers with a novel window structure named the "window grown on facets (WGF)" are described here. In the lasers, window layers are grown on cleaved (110) facets, independent of the internal laser structures. A stable fundamental transverse mode has been obtained up to more than 200mW of output power in the wavelength range of 830nm. A stable operation has been observed beyond 2,000 hours under 100mW and over CW operation at 50℃ and 60℃.

1. Introduction

Recently, high-power semiconductor lasers with a fundamental transverse mode have been strongly required as light sources of optical storage systems, second harmonic generation (SHG) elements, communications, laser printers, and so on. In order to attain reliable high-power operation, several structures with window regions or nonabsorbing-mirror (NAM) ones near the facets have been reported to date[1~5]. A window (NAM) structure is one of the very efficient structures for high-power operation because reliability is mainly limited by facet degradation[6~7]. However, distortion of optical characteristics is often observed in those devices, unless the structures of window layers are rigorously designed and fabricated depending on those of the internal lasers. We have developed a novel window structure named the "window grown on facets (WGF)"[8] to realize high reliability and good optical characteristics in the lasers. In this paper, we will describe improved characteristics and reliability of the WGF lasers.

2. Experimental

In the WGF lasers, window layers are epitaxially grown on cleaved (110) facets, independent of internal laser structures. We used a V-channeled substrate inner-stripe (VSIS) laser[9] in the wavelength range of 830nm as an internal one. A schematic diagram of the WGF-VSIS laser is shown in Fig.1. Window layers are composed of undoped $Al_xGa_{1-x}As$ (x=0.4~0.5). The thickness of the window layers is set as thin as 0.1μm to 0.5μm for obtaining smooth layers. This size is significantly much thinner than that of other window structures reported before[1~4], typically 5μm to 25μm. In this sense, WGF is considered as a kind of facet passivation by AlGaAs thin film.

The fabrication process of the WGF-VSIS laser is described as follows. After cleaving the internal VSIS laser with a cavity length of 480μm, we grew window layers epitaxially on both as-cleaved facets

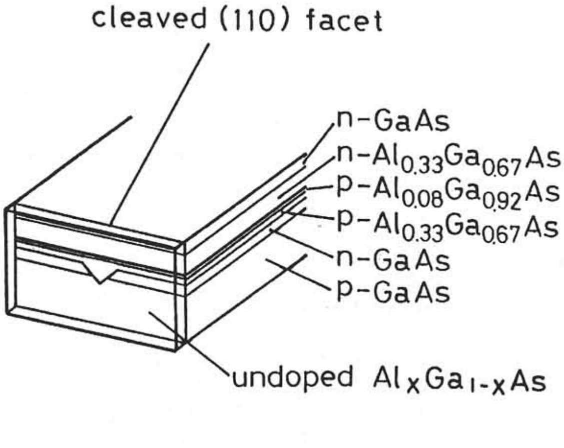

Fig.1 Schematic diagram of the WGF-VSIS structure.

by one-step metal organic chemical vapor deposition (MOCVD). The growth temperature and V/III ratio are chosen as 800℃ and 45, respectively, for obtaining AlGaAs layers of good crystal quality. After MOCVD growth, electrodes are formed by evaporating AuGe-Ni on the n-side and AuZn on the p-side. Additional passivation layers consisting of Al_2O_3 film and Al_2O_3/Si films are coated on the front window layer (Rf=5.5%) and on the back one (Rr=97%), respectively. Finally, the lasers are mounted n-side down on Cu heat sinks with In solder.

3. Results and Discussion

Figure 2 shows the typical light-current (L-I) characteristics of the WGF-VSIS laser in comparison with that of the conventional VSIS laser without WGF, which was obtained from the same wafer as was the WGF laser. As shown in the figure, light output power is observed up to 340mW in the WGF-VSIS laser. This power is about twice as high as the one without WGF, thus confirming a window (NAM) effect in the WGF structure. In addition, the CW threshold current and the external quantum efficiency in the WGF-VSIS laser (Ith=84mA, η=59%) are almost the same as those of the conventional VSIS laser, thus coupling loss is estimated as negligibly small in the WGF-VSIS laser.

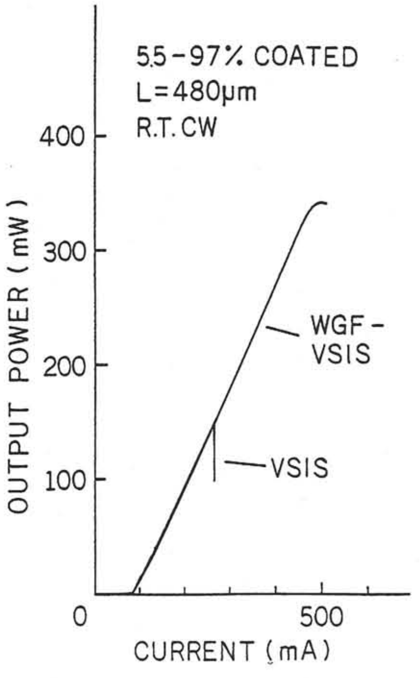

Fig.2 Comparison of light-current characteristics of the WGF-VSIS laser and the VSIS laser.

Figure 3 shows the output power dependence of far-field patterns (FFP) of the WGF-VSIS laser, L-I characteristics of which are displayed in Fig.2. As shown in the figure, a fundamental transverse-mode operation is observed up to at least 200mW in the laser. In this laser, full widths at half maximum (FWHM) of FFP under 50mW CW operation are 8.5° and 24.2° in the directions parallel and perpendicular to the junction plane, respectively. These are almost the same as those of the conventional VSIS laser ($\theta_{\parallel}$=8.7°, $\theta_{\perp}$=25.0°), L-I characteristics of which are also displayed in Fig.2, and the shapes of FFP are quite similar between the two lasers. It is thus confirmed that optical characteristics are not changed after the formation of WGF on cleaved facets of the internal VSIS laser. This is because the window layers in WGF are made very thin, the thickness of which is comparable to that of the passivation layers by dielectric coatings. Furthermore, this property is supposed to be intrinsic to the WGF structure, although window (NAM) structures reported before[1~4] often induce the change of internal optical characteristics due to the difference of the mode profiles between the active region and the window (NAM) region.

Figures 4(a) and 4(b) show results of the preliminary aging test of the WGF-VSIS lasers. The lasers displayed in Fig.4(a) and 4(b) have been operated under 100mW and 150mW CW at 50℃ and under 100mW CW at 60℃, respectively. Stable operation is observed beyond 2,000 hours under both conditions. For comparison, results of the aging test of the VSIS lasers under 100mW CW operation at 50℃ are also shown in

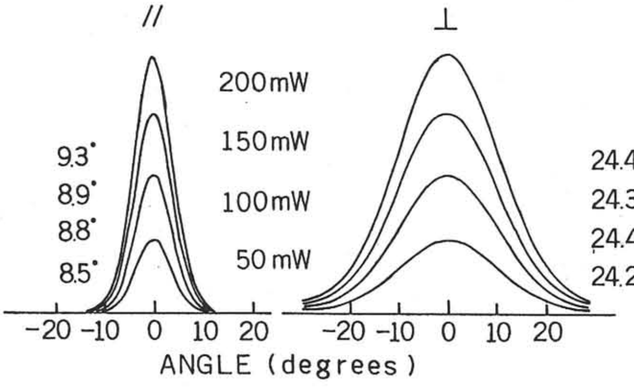

Fig.3 Typical far-field patterns parallel (left) and perpendicular (right) to the junction plane of the WGF-VSIS laser.

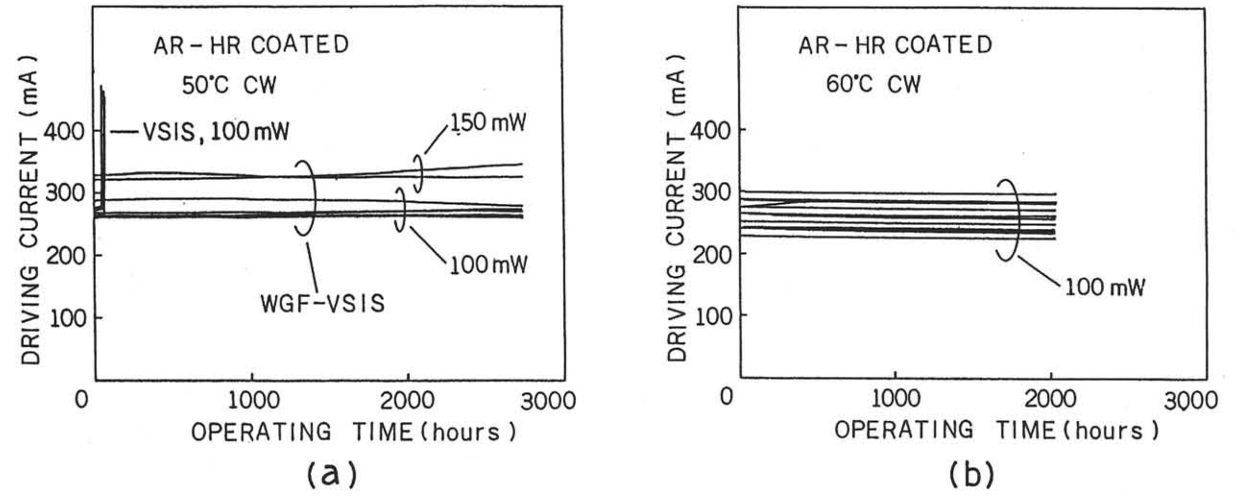

Fig.4 Results of the aging test of the WGF-VSIS lasers and the VSIS lasers. (a) Results under 100mW and 150mW CW operation at 50℃. (b) Results under 100mW CW operation at 60℃.

Fig.4(a). Degradation is observed in 30 ~ 60 hours. Thus, it is confirmed that highly reliable high-power CW operation is attained by forming WGF to the VSIS lasers.

4. Summary

In summary, we have realized a novel window structure, "WGF", in which window layers are grown on cleaved (110) facets of the lasers. It is confirmed that WGF does not change the optical characteristics of the internal lasers. By applying WGF to the VSIS laser, we have attained more than 200mW CW power in a fundamental transverse mode. We have also observed highly reliable CW operation under 100mW and over CW operation at 50℃ and 60℃.

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6. References

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