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1.3 μm GaInNAsSb Lasers with Low Threshold Current Density

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1. Introduction

Since GaInNAs/GaAs is expected to have the strong electron confinement, GaInNAs material is very promising candidate for temperature-insensitive long wavelength lasers. The large characteristic temperature (T_0) over 100 K which is much larger than conventional long-wavelength GaInAsP/InP system, have been reported in GaInNAs lasers[1,2]. Therefore, peltier-free system with low cost for access network can be realized by using GaInNAs system.

We have proposed GaInNAsSb QW that includes small amount of Sb to improve the crystalline quality of GaInNAs[3]. Furthermore, by using GaNAs barrier we obtained 1.31 μm GaInNAsSb laser with low threshold current density (Jth= 570 A/cm^2 @cavity length (L)=900 μm)[4].

In this paper, we report the lowest record on Jth per well (150 A/cm^2/well) for 1.3 μm GaInNAs-based lasers. By using 3QWs as active layers, T_0 of this laser increased up to 105 K.

2. Fabrications and Results

Laser structures were grown on n-GaAs (001) substrates by three step-growth using MOCVD and GSMBE. N-type and p-type $Al_{0.5}Ga_{0.5}As$ cladding layers were grown by MOCVD, and the active region were grown by GSMBE using N radical generated by RF plasma cell as N source. Here, to improve the crystal quality of cladding layer, MOCVD grown $Al_{0.5}Ga_{0.5}As$ layers were utilized. The growth temperature of $Al_{0.5}Ga_{0.5}As$ is 680°C. Active layer consisted of $Ga_{0.63}In_{0.37}N_{0.012}As_{0.972}Sb_{0.016}$ (7.3nm)/ $GaN_{0.019}As_{0.981}$ (16 nm)-3QWs were grown at 460°C. Figure 1 shows TEM image of the active region of the laser. It is clearly observed that the quality of interfaces between well and barrier layers is good and there is no degradation of crystalline quality affected by three step-growth. High resolution X-ray diffraction was also used to confirm the laser structure and to characterize crystalline properties of the lasers. It is found that the fabricated laser structure is good agreement with the designed structure. The FWHM of the -7th satellite diffraction peak is 228 arcsec and it is as narrow as the theoretical value (225 arcsec). Jth of the broad contact lasers with 44 μm width as a function of inverse cavity length is shown in Figure 2. Jth decreased to 450 A/cm^2 for a cavity length of 1000 μm, that corresponds to 150 A/cm^2/well. This value is the lowest record ever reported for Jth per well of 1.3 μm GaInNAs-based lasers[5]. Further, Al-oxide Confined Inner Stripe (ACIS) lasers[6] were fabricated as shown in figure 3. After the mesa structure with 40 μm width was formed, AlAs oxidation was performed at 410°C for 20 minutes to form an 11 μm current flowing aperture. The lasers have the cavity length of 700 μm with cleaved facets. Figure 4 depicts the temperature dependence of the threshold currents for ACIS lasers. T_0 was estimated to be 105 K in the range of 25-65°C. It is confirmed that T_0 was improved from 78 K in SQW laser to 105 K by using 3QWs as active layers, which results from the decrease of Jth/Nw. The decreasing rate of slope efficiencies was -0.012 dB/K in the range of 25-100℃. These results show that GaInNAsSb lasers are very promising novel material for 1.3 μm-range lasers.

3. Conclusion

1.3 μm GaInNAsSb 3QWs lasers with high crystalline quality were successfully grown by three step-growth using MOCVD and GSMBE. The lowest record ever reported on Jth per well (150 A/cm^2/well @L=1000 μm) for 1.3 μm GaInNAs-based lasers was achieved.

References

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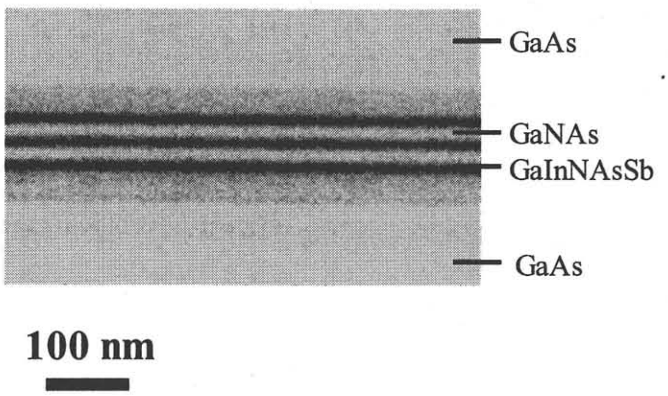

Figure 1. TEM image of the active region of GaInNAsSb 3QWs laser.

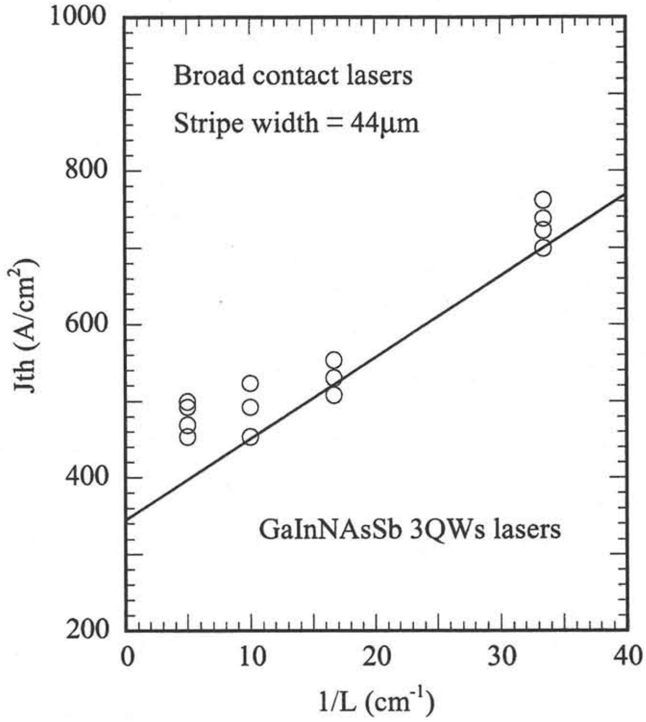

Figure 2. The threshold current density dependence on the inverse cavity length for broad contact lasers.

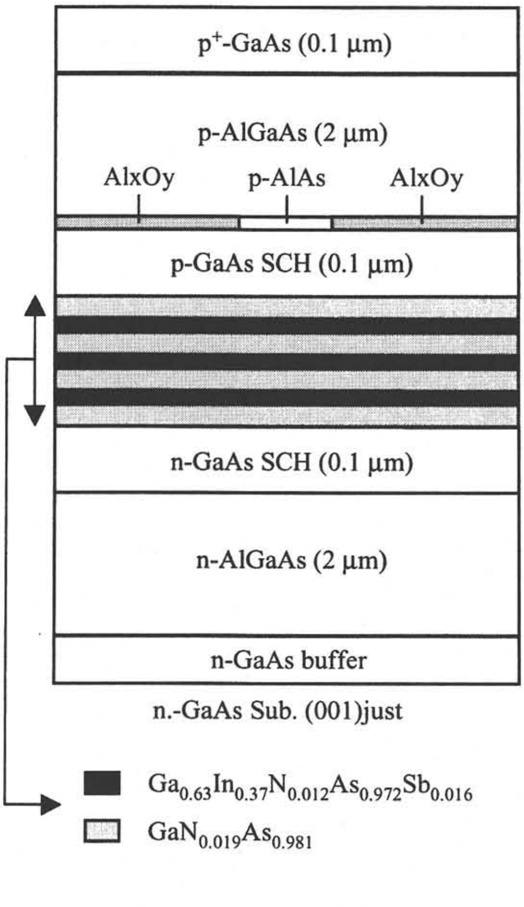

Figure 3. The schematic structure of GaInNAsSb 3QWs ACIS laser.

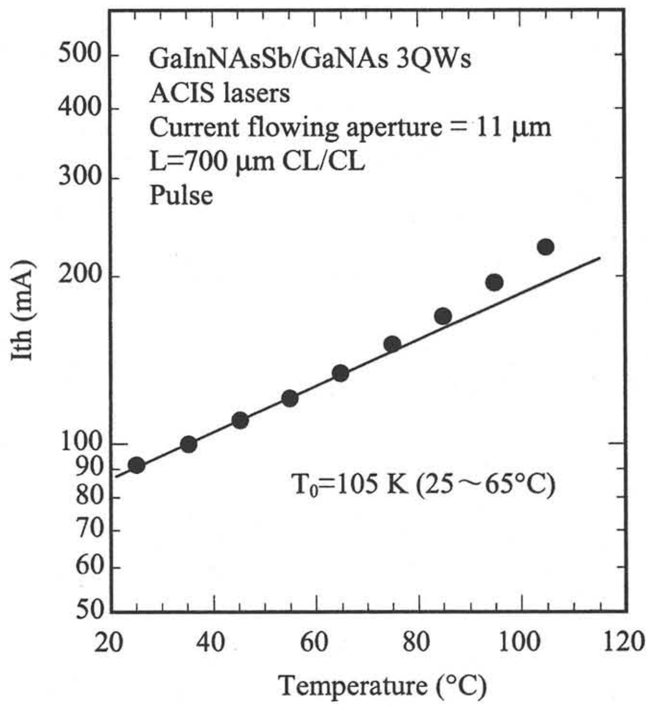

Figure 4. The threshold currents as a function of temperature for ACIS lasers.