1.31μm GaInNAsSb/GaNAs-SQW Lasers Grown by Gas-Source MBE

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Abstract: 1.31μm GaInNAsSb single quantum-well (SQW) lasers were successfully grown on GaAs substrates by gas-source molecular beam epitaxy (GSMBE). We obtained the very low threshold current density (Jth) of 570A/cm^2 at 900μm-long cavity.

Introduction: GaInNAs lasers emitting at 1.3μm-range grown on GaAs substrates have been attracting much interest because they are expected to be pertier-free optical source for access network or active layer material for 1.3μm vertical cavity surface emitting lasers (VCSEL). We reported the high performance CW lasing characteristics of 1.26μm-GaInNAsSb/GaAs SQW lasers (Ith=12.4mA@25^{o}C, T_0=157K(@25-85^{o}C)[1]. However, the oscillating wavelength was needed to increase up to more than 1.3μm.

In this paper, we investigated the photoluminescence (PL) characteristic dependency by increasing N composition in GaInNAsSb/GaAs-SQW lasers and PL characteristic dependency by changing barrier material from GaAs to GaNAs[2]. As the results, we obtained the very low Jth of 570A/cm^2 at 1.31μm by room-temperature pulsed operation.

Fabrications and Results; To investigate the effect of increasing N composition of well layer, $Ga_xIn_{1-x}N_{1-y-0.016}As_ySb_{0.016}$/GaAs SQW lasers [1] were grown on n-GaAs substrates by GSMBE in which the N source is N radical generated by RF plasma cell, and the other group V were supplied by AsH_3 and PH_3. The lasers consisted of n-, p-GaInP cladding, a highly strained SQW active layer (7.3nm-thick), and 130nm thick GaAs SCH layers located on both sides of SQW layer. The indium compositions (1-x) were varied from 0.35 to 0.39, and the N_2 flow rates were varied from 0.05ccm to 0.15ccm. The N compositions of well layer were determined by PL-energy shift between as-grown $Ga_xIn_{1-x}N_{1-y-0.016}As_ySb_{0.016}$/GaAs SQW and as-grown $Ga_xIn_{1-x}As_{0.984}Sb_{0.016}$/GaAs SQW. Figure 1 shows the relationship between N_2 flow rate and N composition in the well under the same growth rate. From this figure, we can see that N incorporation rates decrease with increasing composition of indium, which is probably caused by the weakness of In-N bond as compared with Ga-N bond. The N were incorporated lineally up to 0.9% into the SQW layer, and the as-grown PL-wavelength reached 1.34μm in the case of In=37%. However, there are serious problems with PL-intensity in the case of GaAs barrier as mentioned below.

To overcome the deterioration of PL intensity, we investigated SQW with GaNAs barrier (30nm-thick) as shown in figure 2. Although the N_2 flow rates during well and barrier layer were set to be identical, the incorporation rate of N in the barrier is about 2 times larger than that in the well. Figure 3 shows PL intensity versus PL wavelength before and after annealing with respect to lasers with GaNAs barrier and lasers with GaAs barriers, of which well layers consisted of the various compositions of N and indium. The annealing temperatures were varied from 550^{o}C to 700^{o}C by 50^{o}C to improve the quality of lasers, and the all PL data were plotted in figure 3. PL intensity of as-grown lasers with GaNAs barrier is as low as that of lasers with GaAs barrier, but PL intensity of lasers with GaNAs barriers becomes much stronger than that of lasers with GaAs barrier after annealing, which means that crystal quality of lasers with GaNAs barrier is superior to GaAs barrier lasers.

We fabricated broad contact lasers with $Ga_{0.63}In_{0.37}N_{0.009}As_{0.975}Sb_{0.016}/GaN_{0.02}As_{0.98}$-SQW layer. $GaN_{0.02}As_{0.98}$ barrier has the bandgap wavelength of 1.08μm. Figure 4 shows Jth versus the inverse cavity length for lasers with GaNAs barriers mentioned above and lasers with GaAs barriers that emits at 1.26μm reported before [1]. The lasing wavelength was 1.31μm as shown in the inset of figure 4. The very low Jth of 570A/cm^2 was obtained at 900μm-long cavity under room-temperature pulsed operation, which is the almost same value with the best results ever reported for GaInNAs-based lasers that emits more than 1.29μm[2]. The gain coefficients (G_0) were estimated as 1300cm^{-1} for GaNAs barrier lasers and 1700cm^{-1} for GaAs barrier lasers. We can say that this material is very promising for realizing 1.3μm VCSEL.

References (1) H. Shimizu et al., Electron. Lett., vol. 36, p. 1701, 2000 (2) S. Illek et al., IPRM'00, THA1.1, 2000

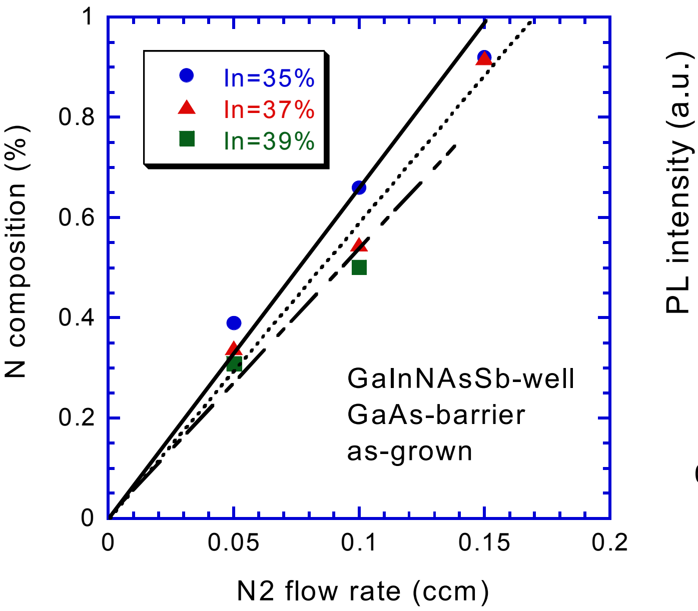

Figure 1 N composition vs. N_2 flow rate in GaInNAsSb/GaAs SQW

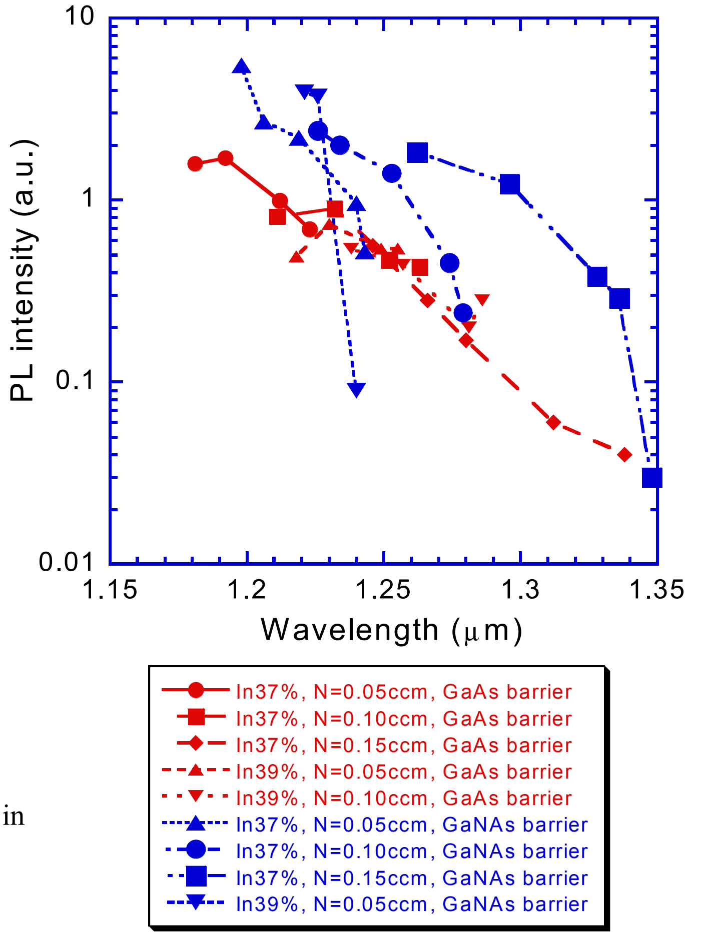

Figure 3 PL intensity vs. PL wavelength for GaNAs-barrier lasers and GaAs-barrier lasers

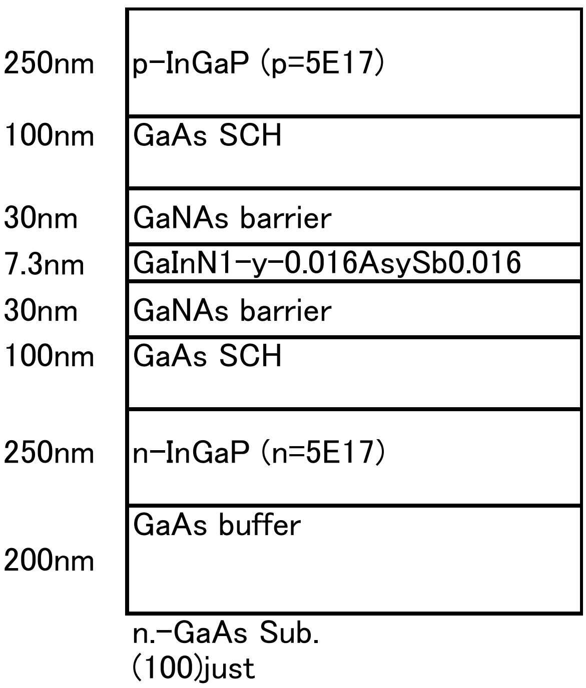

Figure 2 The schematic laser structure

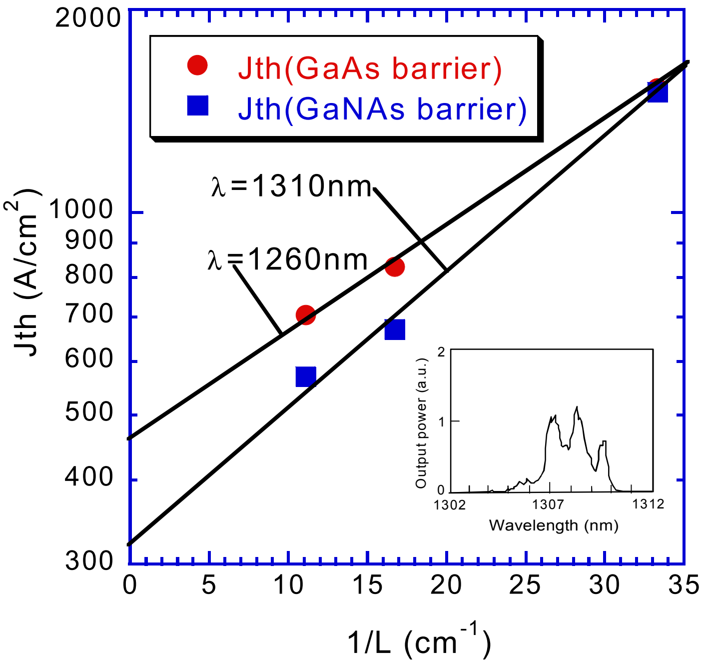

Figure 4 Jth vs. 1/L for GaNAs-barrier lasers and GaAs-barrier lasers