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GaInNAs/GaAs Quantum Well Lasers Grown by Chemical Beam Epitaxy

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1. Introduction

We demonstrated the first lasing operation of GaInNAs/GaAs quantum well laser with a wavelength range of 1.2-1.27μm grown by CBE with high characteristic temperature (T_0 = 270K).

Semiconductor lasers emitting in 1.2-1.3μm wavelength ranges are important for high speed optical data links and optical networks. A GaInNAs alloy that can be grown on GaAs substrate was proposed to solve the problem as long wavelength materials because the system is considered to have a large bandgap bowing and a strong electron confinement capability [1]. A GaInNAs/GaAs long-wavelength vertical cavity surface emitting laser (VCSEL) is attractive [2,3]. Recently, GaInNAs/ GaAs strained quantum well (QW) lasers were reported by several groups [4-8]. However, the threshold current of such devices is unsatisfactory. We have examined the growth of GaNAs and GaInNAs grown by CBE using radical nitrogen in a radio frequency (RF) radical beam cell with ion trap.[9-12].

2. Experimental

CBE Growth

The growth of strained GaInNAs/GaAs double quantum well (DQW) with the well width of 80Å was done by chemical beam epitaxy (CBE) using TEGa, TMIn, AsH_3, and radical nitrogen cracked in a radio frequency (RF) plasma cell. The growth temperature of GaInNAs DQW was 480°C and the growth rate was 1.7μm/h. Three types of GaInNAs/GaAs DQW were used for laser active layer as shown in Table 1.

Table 1 Composition and lasing wavelength of GaInNAs/GaAs DQW.

Sample	A	B	C
In	35%	37%	37%
N	0.3%	0.3%	0.5%
λ	1.195μm	1.231μm	1.265μm
L_{cavity}	750μm	800μm	780μm

Laser Structure

Figure 1 shows the schematic structure of the fabricated edge emitting GaInNAs/GaAs laser. In this study, the active layer was grown by CBE. The cladding layers were grown by MOCVD because of lack of cladding layer material sources in our CBE system. Thus, two interfaces between CBE and MOCVD growth were exposed to the air. A 1.5μm thick n-$Al_{0.5}Ga_{0.5}As$ cladding layer, 1.5μm thick p-$Al_{0.5}Ga_{0.5}As$ cladding layer, and 0.1μm thick p-GaAs capping layer were separately grown by MOCVD at 670°C with the carrier concentration of $8\times10^{17}cm^{-3}$ (Se), $7\times10^{17}cm^{-3}$ (C), $1\times10^{19}cm^{-3}$ (C), respectively. Broad area 50μm stripes were formed and the cavity length was 750μm with cleaved facets.

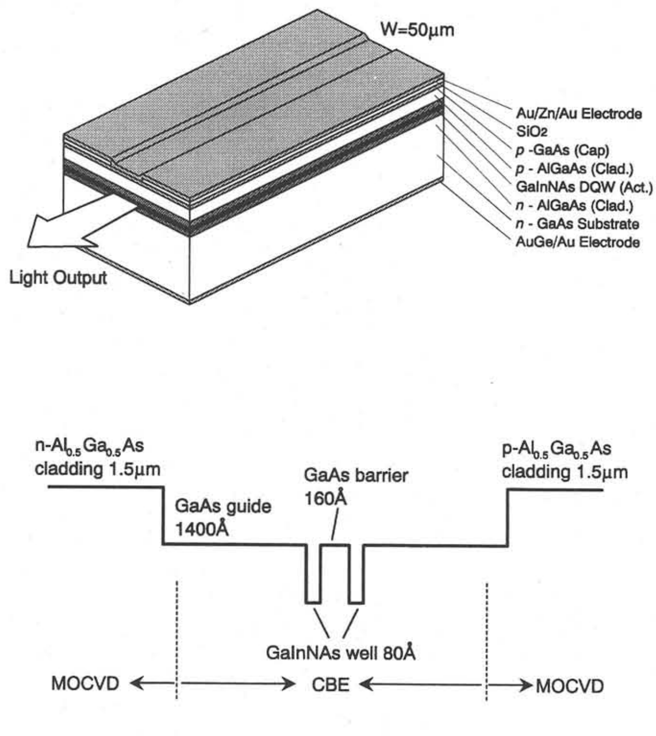

Fig. 1 Schematic structure of broad area GaInNAs/GaAs DQW laser. Schematic conduction band diagram is also shown.

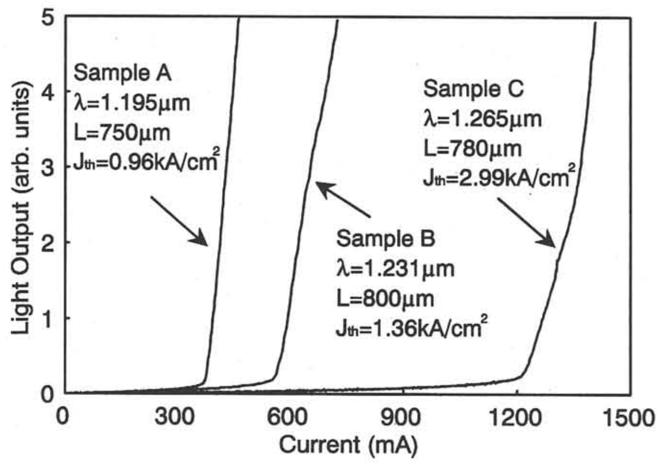

Fig. 2 L-I characteristics of GaInNAs/GaAs DQW lasers with three types of GaInNAs/GaAs DQW under pulsed condition.

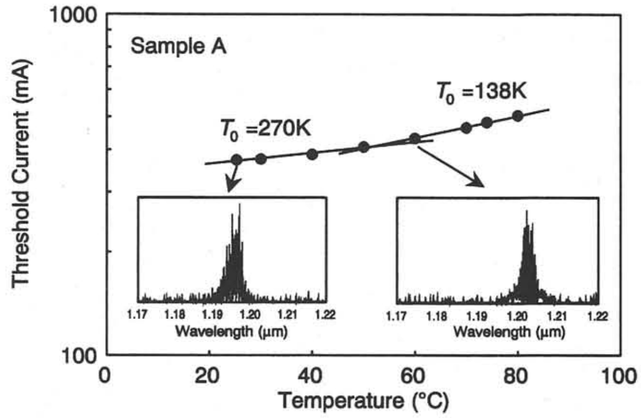

Fig. 3 Temperature dependence of threshold current of GaInNAs/GaAs laser diode. T_0 of 270K for 25-50°C and 138K for 50-80°C were obtained. Inset figures show emission spectra at 25 and 60°C, respectively.

3. Results and Discussions

Figure 2 shows room temperature L-I characteristics of GaInNAs/GaAs DQW lasers with different N compositions under pulsed condition (1msec, 0.1% duty). The lasing wavelength of sample A was 1.195μm and threshold current density was 960A/cm^2. This value was closed to the lowest value of GaInNAs lasers ever reported. In the case of nitrogen free $Ga_{0.65}In_{0.35}As$/GaAs DQW laser, the threshold current density was relatively high as 660A/cm^2. This reason is mainly due to the influence of 3 step regrowth without any treatment. As-grown $Ga_{0.65}In_{0.35}As$/GaAs DQW sample shows a high quality PL FWHM of 22meV. The threshold current density of both GaInAs and GaInNAs laser will be reduced if 1 step growth process is used. On the other hand, 1.265μm lasing operation was demonstrated. The threshold current density was as high as about 3kA/cm^2. Figure 3 shows the operating temperature dependence of threshold currents for sample A (λ=1.195μm). The characteristic temperature T_0 of 270K (25-50°C) and 138K (50-80°C) was demonstrated. This T_0 is the highest value for edge emitting long wavelength lasers.

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