GaAs-$Al_xGa_{1-x}As$ Multiquantum Well Visible Lasers Grown by Molecular Beam Epitaxy

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Quantum well structures are very attractive for lasers operating in visible wavelength range. Several works(1) on visible cw single quantum well diode lasers in $Al_xGa_{1-x}As$-$Al_yGa_{1-y}As$ system have been reported. However, there are few reports on cw operation of visible GaAs-$Al_xGa_{1-x}As$ quantum well diode lasers. In this paper, we fabricated 25 Å-GaAs well and 50 Å-$Al_xGa_{1-x}As$ ($x = 0.22$ or 0.28) barrier multiquantum well (MQW) lasers grown by molecular beam epitaxy (MBE), and obtained the current injection cw room-temperature laser operation at wavelength as short as 7690 Å and at threshold current (I_{th}) as low as 70 mA.

The MBE growth was carried out in a Varian MBE/GEN II. Particular attention was paid to lowering partial pressures of active gases, such as H_2O and CO in the growth chamber, careful in-situ substrate heat treatment and sufficient degassing of source materials. Highly-pure elemental source materials, especially six nines purity Be, in place of usual three nines six purity(2) were used. MQW samples were grown on Si-doped (001) GaAs substrates at 700°C, which was selected as the optimum growth temperature considering the MQW quality dependence on growth temperature.(3) The growth rate calibration of ultra thin layers in the MQW structure region was accomplished by bevel cross sectioning and photoluminescence (PL) techniques. Three different MQW structures, consisting of four GaAs quantum wells (thickness L_Z) and three $Al_{0.38}Ga_{0.62}As$ barriers (thickness L_B), were grown: (1) $L_Z = 25$ Å, $L_B = 50$ Å, (2) $L_Z = L_B = 50$ Å, (3) $L_Z = L_B = 100$ Å. The 77°K photoluminescence spectra from these structures are shown in Fig. 1. The arrow shows the desired peak wavelength. Desired and measured well thicknesses agree well within experimental error in the comparison of the calculated heavy hole transitions and the photoluminescence peak wavelengths.

Figure 2 shows the structure of a visible MQW laser with a native-oxide-stripe geometry. Typical stripe width and cavity length are about 3 μm and 250 μm, respectively. Contact layer and buffer layer are 0.5 μm thick, $\sim 3 \times 10^{18}$ cm^{-3} Be-doped and Si-doped, respectively. Upper and lower $Al_{0.48}Ga_{0.52}As$ cladding layers are 2 μm thick, $\sim 2 \times 10^{18}$ Be-doped and Si-doped, respectively. To increase the optical confinment factor for the active layers, a separate confinment hetero(SCH) structure was adopted, as shown in Fig. 2. The distance between two cladding layers is 700 Å or 1500 Å. The MQW active region consists of four 25 Å or 50 Å thick GaAs quantum wells and three 50 Å thick $Al_xGa_{1-x}As$ ($x = 0.22$ or 0.28) barriers. The active regions are $\sim 1 \times 10^{17}$ cm^{-3} Si-doped. Obtained results are summarized in Table 1. Lasing and photoluminescence peak wavelengths were found to vary with the optical waveguide structure and the barrier height, even for MQW lasers with the same well width. Obtained shortest cw lasing wavelength was 7690 Å at room temperature. This value is the shortest oscillation wavelength for quantum well diode lasers with GaAs wells among those previously reported. Typical I-L curve and lasing spectra are shown in Fig.3. Threshold current of the 25 Å-well MQW lasers is twice as high as the 50 Å-well MQW lasers. This increase in threshold current may be because of the decreased efficiency of the carrier injection into narrower wells.

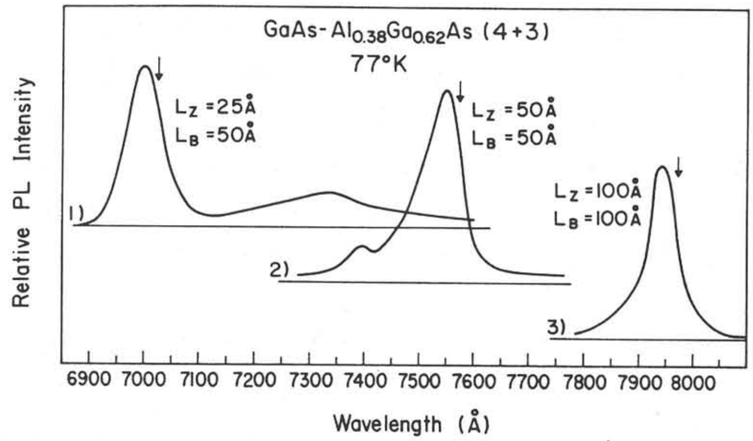

Fig. 1. Photoluminescence spectra for MQW structures.

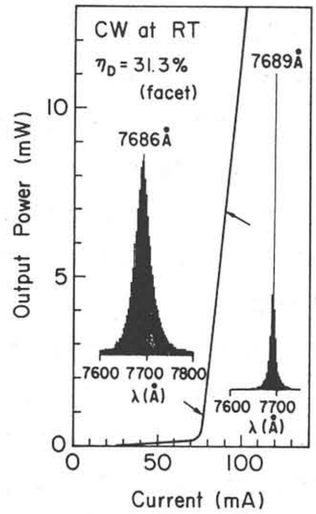

Fig. 3. CW I-L characteristics of a 25 Å-well MQW laser.

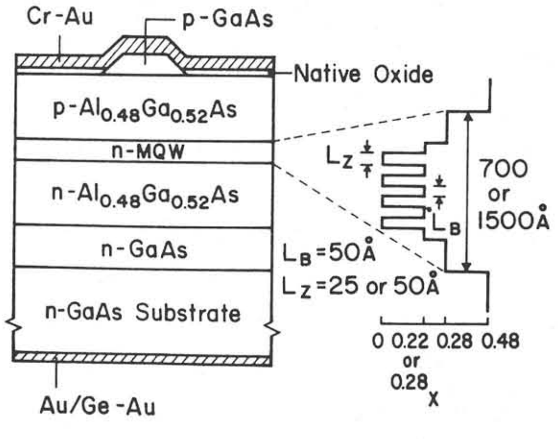

Fig. 2. MQW laser structure.

Table 1. MQW laser characteristics at room temperature.

L_z	CW I_{th} (Minimum)	Lasing Wavelength	PL Peak Wavelength
25Å	70 mA	7690~7780 Å	7630~7680 Å
50Å	42 mA	7890~8080 Å	7800~8000 Å

1) C. Lindström et al., Appl. Phys. Lett. 42, 134 (1983)
2) P. K. Bhattacharya, J. Appl. Phys. 53, 6391 (1982)
3) C. Weisbuch et al., Appl. Phys. Lett. 38, 840 (1981)