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Low Threshold Current InGaAs/InGaAlAs MQW Lasers Grown by Gas Source Molecular Beam Epitaxy

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The InGaAs/InGaAlAs multiple quantum well (MQW) lasers are very promising as light sources for the long wavelength (1.3–1.5 μm) optical fiber communication systems. This material system has a large conduction band discontinuity (0.5 eV) and a small valence band discontinuity (0.2 eV). Therefore, enhanced quantum effects are expected together with a small hole pile up in the valence band.

So far, these lasers have been grown by molecular beam epitaxy (MBE) and metal organic vaper phase epitaxy (MOVPE). In this paper, InGaAs/InGaAlAs MQW lasers have been grown by gas source (GS)-MBE for the first time. Room temperature CW operation with a very low threshold current was achieved. Furthermore, an enhancement in the relaxation oscillation frequency was obtained in comparison with the InGaAs/InGaAsP MQW lasers with the same structure.

The structure of the InGaAs/InGaAlAs MQW laser is shown in Fig.1, together with its energy band diagram. It consists of InP clad layers, InGaAsP guide layers and an InGaAs/InGaAlAs MQW active layer (3 or 6 wells). The barriers are InAlAs or InGaAlAs (Al=0.25) layers. The well width and the barrier width are 90 Åand 30 Å, respectively. The lowest threshold current density is 0.93 kA/cm^2 at a cavity length of 1000 μm. The important point in the structure shown in Fig.1 is that it is possible to use the same process as that used for the InGaAs/InGaAsP system for fabricating a burried-hetero (BH) structure and/or a DFB structure.

Figure 2 shows the *I-L* characteristic at room temperature for the MQW laser (InAlAs barriers, 6 wells, cavity length = 400 μm) formed into the BH structure using a liquid phase epitaxy (LPE). The threshold current is as low as 9.6 mA. This is the lowest value reported for the InGaAs/InGaAlAs MQW lasers. The lasing wavelength is 1.52 μm, and the maximum differential quantum efficiency is 0.21 W/A for one facet.

Figure 3 shows the output power dependence of the relaxation oscillation frequency f_r for the ridge structure lasers with InAlAs barriers (6 wells). The mesa-width is 2.5 μm, and the cavity length is 400 μm. The threshold current is 20 mA. For comparison, results for the GS-MBE grown InGaAs/InGaAsP MQW lasers with the same structure are shown. It is known that f_r for InGaAs/InAlAs MQW lasers is larger than that for InGaAs/InGaAsP MQW lasers. This enhancement of f_r is considered to be due to the larger gain coefficient for the InGaAs/InGaAlAs MQW lasers than that for the InGaAs/InGaAsP MQW lasers.

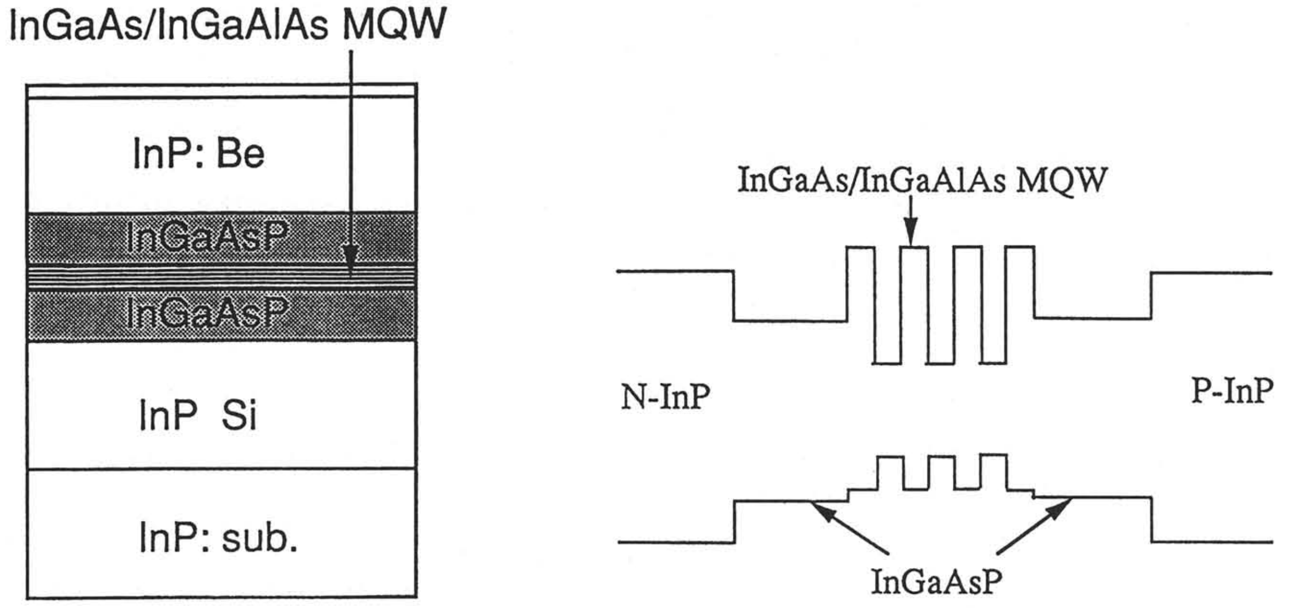

Fig.1 Structure of the InGaAs/InGaAlAs MQW laser grown by GS-MBE and its energy diagram.

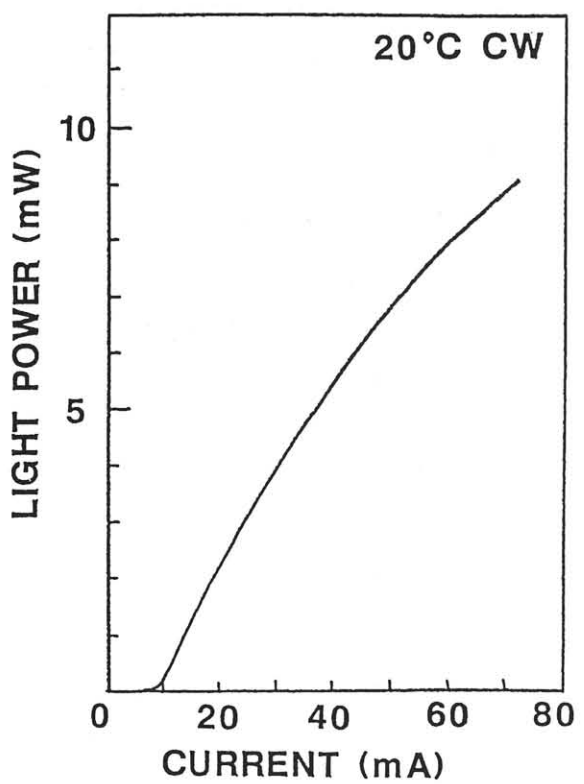

Fig.2 Room temperature I-L characteristic of the BH InGaAs/InAlAs MQW laser.

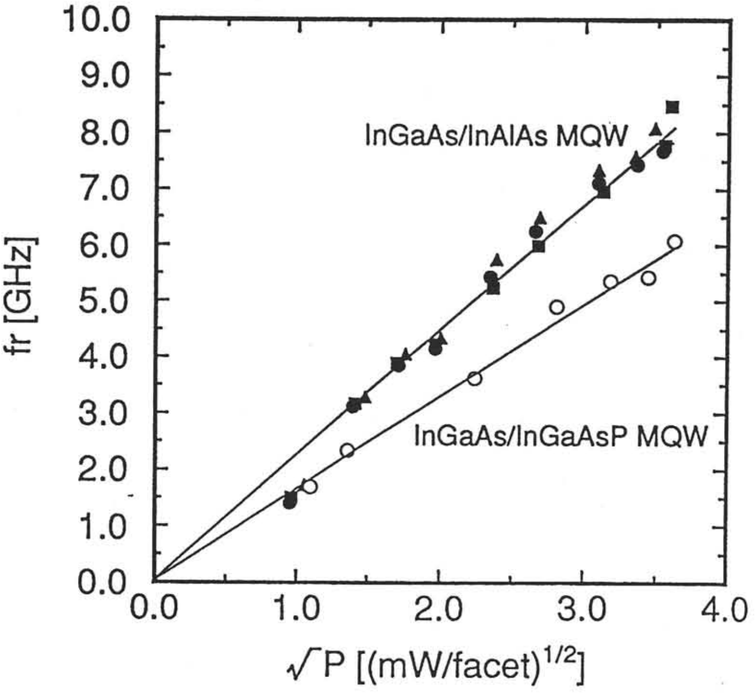

Fig.3 Output power dependence of the relaxation oscillation frequency f_r