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Polarization Characteristics of Crescent-Shaped Tensile-Strained GaAsP/AlGaAs Quantum Wire Lasers

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1. Introduction

Quantum-wire (QWR) structures fabricated using growth characteristics on V-grooved substrates proved themselves advantageous for high efficiency GaAs/AlGaAs lasers [1]. A spontaneous vertical quantum well (SVQW) formed in a V-groove during the growth of $Al_xGa_{1-x}As$ is also useful for efficient carrier injection to the QWR region [2,3]. On the other hand, upon introduction of tensile strain to the active region, as in GaAsP/AlGaAs, the polarization properties (TE mode/ TM mode) of the lasers can be varied by properly choosing the strain quantity and the size of the QWR [4].

In this paper, polarization characteristics of crescent-shaped tensile-strained GaAsP/AlGaAs QWR lasers are reported. A highly efficient TM-polarized laser operation with the threshold current density for each QWR as low as $500A/cm^2$ has been attained.

2. Fabrication of QWR Lasers

The $[01\bar{1}]$-oriented V-grooves with (111)A sidewall faces were fabricated on n^+-GaAs (100) substrates using photolithography and chemical wet etching [2]. The V-grooves are 2.1μm wide at the top and 1.5μm deep with a period of 3μm. The GaAsP/AlGaAs QWR structures were grown with low-pressure metalorganic vapor phase epitaxy (MOVPE) as described elsewhere [4]. The QWR laser structure is of a double-QWR active region in a separate confinement heterostructure (SCH) as illustrated in Fig. 1. The QWRs are vertically sandwiched by SVQWs. The crescent-shaped QWRs were 11nm thick at the center and 80nm wide when the growth time of GaAsP layer, t_{well}, was 20 sec. The tensile strain in the GaAsP region is estimated to be +0.4%. Due to the relatively wide lateral dimension, the strain nature, hence the polarization, is expected as similar to that in (100) quantum-well layers (QWLs). The QWR lasers were fabricated with a 50μm-wide stripe p-side metal contact and uncoated cavity mirrors.

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3. Results and Discussion

Figure 2 shows the photoluminescence (PL) spectra measured from 5K to 280K at the cross section of a QWR sample. Three distinct peaks are observed at 5K, except for one from the GaAs substrate (~820nm). These peaks are identified as the luminescence from the top (100) QWL (726nm) and the bottom QWRs (743nm, 770nm), respectively, as revealed by spectrally and spatially resolved cathodoluminescence measurements [2,3]. The relative intensity of the QWR luminescence increases up to ~120K, showing an efficient carrier confinement to the QWRs.

Figure 3 shows the polarized and unpolarized light output versus current characteristics of the QWR laser pulsed-operated (500ns duration, 500μs period) at room temperature. Due to the tensile strain in the QWR, the TM-polarized light contributed from the electron-light hole recombination is much dominant. The TE/TM polarized light intensity ratio was dependent on the QWR thickness.

Figure 4 shows the polarized lasing spectra at various injection currents. It is obvious that the lasing peak of

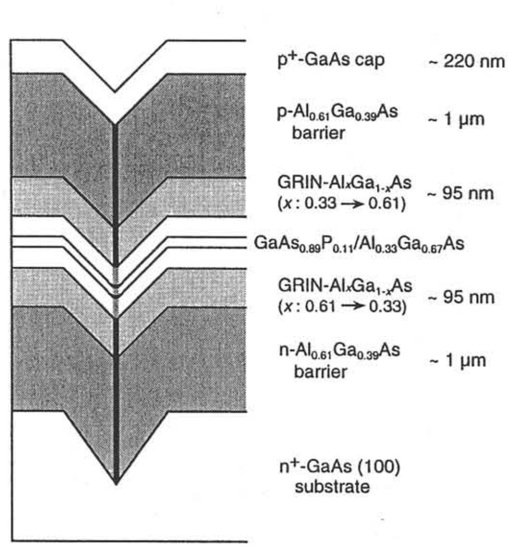

Fig. 1 Tensile-strained GaAsP/AlGaAs QWR laser structure.

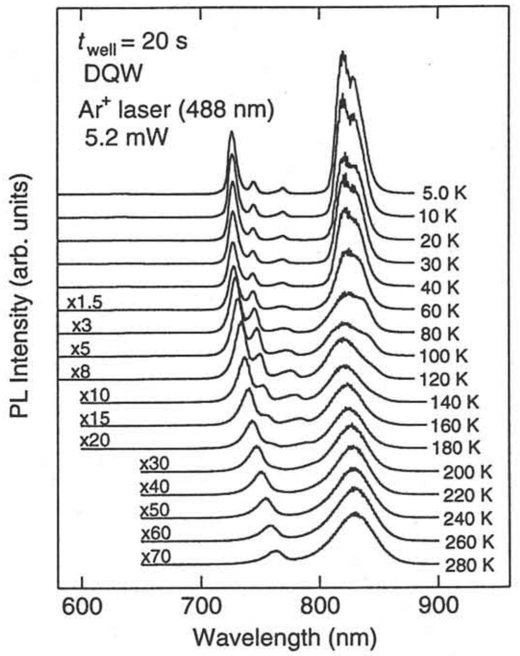

Fig. 2 Temperature dependence of PL spectra of the QWR laser structure.

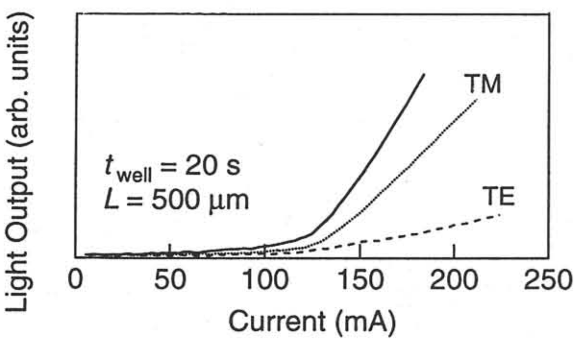

Fig. 3 Light-output versus current characteristics of the QWR laser. Room temperature, pulsed operation.

the QWR (780nm) is mostly of the TM mode, while the TE mode which starts lasing at higher injection levelis due to the QWL (765nm). The lasing positions at each injection level are confirmed by the near-field patterns shown in Fig. 5.

As each metal-electrode stripe contains 17 V-grooves underneath, the threshold current for a single QWR region is estimated to be 7.3mA, corresponding current density being as low as $500\mathrm{A/cm}^2$.

4. Conclusion

A highly efficient TM-polarized laser operation with the threshold current density for each QWR as low as $500\mathrm{A/cm}^2$ has been attained with an MOVPE grown crescent-shaped tensile-strained GaAsP/AlGaAs QWR laser.

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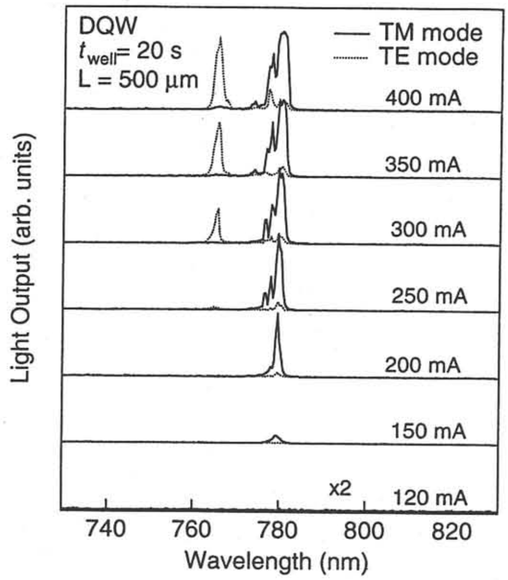

Fig. 4 Polarized lasing spectra of the QWR laser.

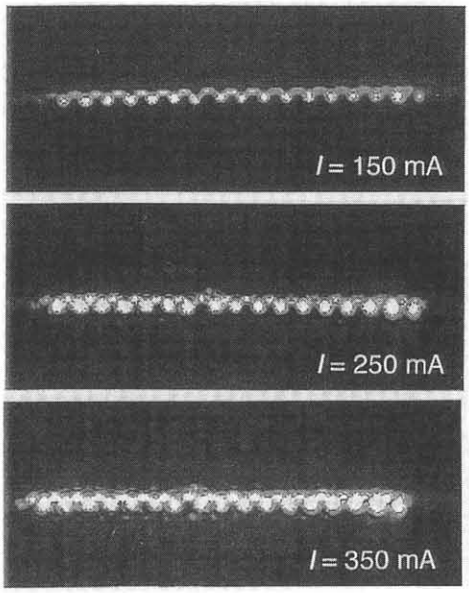

Fig. 5 Near-field patterns of the QWR laser at various current levels.

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