3-2 Visible Light-Emitting Semiconductor Lasers of Double Heterostructure

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$Ga_{1-x}Al_xAs$ semiconductor lasers of double heterostructure were prepared with changing X from 0 to 0.37. The thresholds of the laser diodes obtained were below 8×10^3 A/cm^2 in the range of 6930Å $\leq \lambda_L \leq$ 9000Å at room temperature and below 6×10^2 A/cm^2 in the range of 6200Å $\leq \lambda_L \leq$ 8500Å at 77K with high reproducibility. At room temperature, the lowest threshold current density for 6930Å was 5.0×10^3 A/cm^2. It was also found that the change of the threshold current density was much slower in comparison with the results so far obtained.

1) Introduction

By making use of double heterostructure, Hayashi[1)] et al. succeeded to reduce the threshold current density of GaAs lasers. Since then, many studies have been done in the field of semiconductor lasers along their line. However, almost all of them have concerned with the heterostructure composed of GaAs active region, the results of which are necessarily restricted to the wavelength out of the visible region. To the author's knowledge the shortest wavelength attained at room temperature is 7450Å for $Ga_{1-x}Al_xAs$ of the double heterostructure.[2)] In the present paper is described the laser operations of $Ga_{1-x}Al_xAs$ diodes of which emission band are extended down to 6920Å at room temperature and to 6200Å at 77K. As a result of the double heterostructure adopted, the threshold current density is as low as 5000A/cm^2 and 300A/cm^2 at room temperature and at 77K, respectively, and nearly constant throughout the emission band covered.

2) Fabrication Method

The double heterostructure wafers were grown by continuous epitaxial process[1)] using a high purity graphite boat which consists of five solution receptacles. The composition of each solution is shown in Table 1, together with the composition and the thickness of the resulting solid layers. The role of the pure Ga solution in the second receptacle is to prevent the transportation of Al in the first solution into the third receptacle where the active region is grown. Glassy carbon was used for the seed holder, so that droplets of the solution would not remain during epitaxial process. The solid compositions X_1 and X_3 were estimated with the aid of X-ray micro-analysis, and X_2 was determined from the peak of laser emission. Broad contacts of Au-Ge and Au-Zn on the n- and p-sides, respectively, were formed by the vapor deposition. The dimensions of diodes were 500μ long x 250μ wide x 150μ thick.

3) Experimental Results

Figure 1 shows the experimental results of the relation between threshold current density and lasing wavelength, where the results of Kressel et al.[3)] for single heterostructure $Ga_{1-x}Al_xAs$ lasers are also shown. It should be noted that both the lasing wavelength and the threshold

Solution	Liquid composition (gram)			Solid composition	Thickness (μ)
	Ga	Al	Dopant		
1	10	62.5×10^{-3}	0.5 (Sn)	$x_1 \approx 0.7$	3 − 6
2	10	——	——	——	——
3	10	$0\text{-}3.14 \times 10^{-3}$	undope or Zn	$x_2 \approx 0.0\text{-}0.37$	0.5 − 1.0
4	10	62.5×10^{-3}	0.1 (Zn)	$x_3 \approx 0.7$	1.0 − 1.5
5	10	——	0.4 (Zn)	$x_4 = 0$	1 − 3

Table 1 The composition of each solution, and the composition and the thickness of the resulting layers

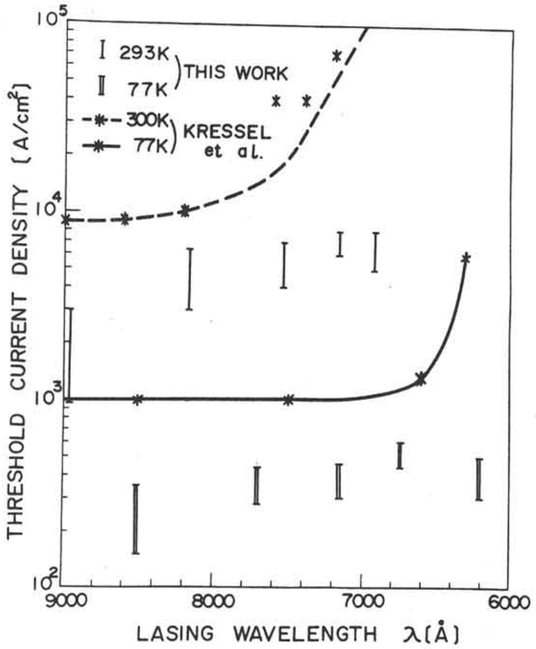

Fig. 1 Threshold current density as a function of the lasing wavelength at room temperature and 77K

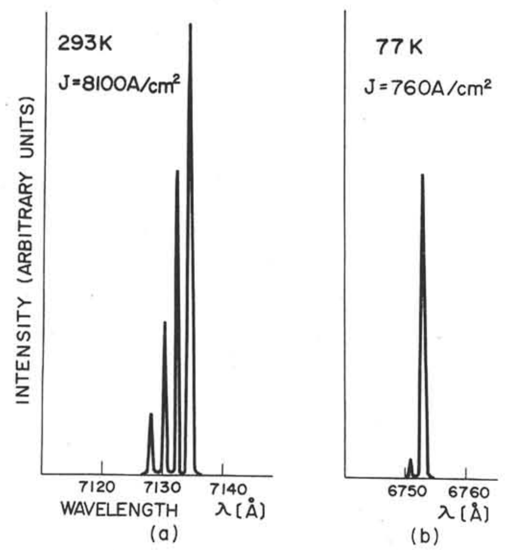

Fig. 2 Emission spectra of a laser diode at room temperature and 77K

current density are far below the results obtained by Kressel et al. ; 1) the shortest lasing wavelength observed is 6930Å at room temperature and 6200Å at 77K. 2) all thresholds are below 8×10^3 A/cm^2 and below 6×10^2 A/cm^2 at room temperature and at 77K, respectively. Furthermore, it is seen that the rate of the emission peak wavelength is much slower than that in the case of single heterostructure. The lowest threshold current density for 6930Å at room temperature was 5×10^3 A/cm^2 and that for 6200Å at 77K was 300A/cm^2. Figure 2 shows the emission spectra of a diode in the vicinities of 7135Å at room temperature and of 6753Å at 77K for the current density slightly above the thresholds. Several modes of oscillation are observed at room temperature, while at 77K a single mode oscillation is observed. Similar results were obtained for a number of diodes fabricated in the same way.

4) Acknowledgement

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5) References

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