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B—2—2 Low Threshold Current 1.3 µm InGaAsP Buried Crescent Lasers

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A low threshold current is one of the important factors to reduce the junction temperature rise and to obtain the cw operation at high temperature. It has been reported that the threshold current increases remarkably when the active region width w becomes less than 1.5 µm in the buried heterostructure (BH) lasers. Thus, the reduction of the threshold current by narrowing the stripe width had the limitation and the threshold current less than 10 mA was rather difficult to obtain. In this paper, we examine the threshold current in the BC lasers with narrow active region and the minimum threshold current of 8 mA at room temperature was obtained.

The fabrication procedure for the BC lasers was described elsewhere(1). In that case, the active region was grown in the dovetail-shaped groove and the width of the grooves becomes more than 2 µm by conventional photolithography and etching technique. This time, we obtained the active region width w less than 2 µm. The fabrication technique for the narrower active region is as follows: The stripe windows as wide as about 2 µm were made parallel to the <011> direction on the (100) surface. The grooves were formed by etching through the stripe windows. The cross-sectional view of such a groove is shown in Fig. 1. Growing the active region in the lower part of the groove, we can get the active region less than 2 µm wide. Fig. 2 shows the s.e.m. photograph in case of the active region width w = 0.85 µm.

Fig.3 shows the dependence of the threshold current I_{th}^{cw} at room temperature on the active region width w. In this case, the active region was 0.1-0.3 µm thick and the cavity length L was 300 µm. From Fig. 3 the lasing threshold is found to be approximately proportional to the active region width w. The threshold current density J_{th}^{cw} was about 2.8 KA/cm^2. This value of J_{th}^{cw} is reasonably low for the narrow stripe lasers, though the minimum value is 1.6 KA/cm^2 in the lasers with the broad-area electric contact(2). In the case of the active region width w = 0.85 µm, J_{th}^{cw} was 3.1 KA/cm^2 and no increase in the threshold current was observed. This suggests that the current is well confined within the active region and the unduration along the active region side-walls has less influence in the BC lasers than in the BH lasers. The latter is thought to come from the structural difference of the BC and BH lasers. The cross-section of the active region of the BH lasers is rectangular and the side-walls are made by the etched surfaces. On the other hand, the cross-section of the active region of the BC lasers are crescent-shaped and the thickness gradually goes to zero at the etched side-walls.

Fig. 4 shows the power-current characteristics obtained from the same diode shown in Fig. 2, which has a low threshold current I_{th}^{cw} of 8 mA. The differential quantum efficiency η in cw operation was 30 % per facet near threshold. The diode can operate continuously up to more than 80°C.

In summary,

(1) the active region, less than 2 µm wide, was grown in the lower part of the groove etched with conc HCl,

(2) the minimum threshold current 8 mA was obtained with the cavity length L =300 µm,

(3) the threshold current density J_{th}^{cw} was approximately 2.8 KA/cm^2 and

(4) even for the narrowest active region (w=0.85 µm), the increase in the threshold current was not detected, which means the current is well confined within the active region and the unduration of the etched walls has little influence on the threshold current in BC lasers.

Reference

(1) T.Murotani, E.Oomura, H.Higuchi, H.Namizaki and W.Susaki, Elec. Lett. 16 (1980) 566

(2) R.E.Nahory and M.A.Pollack, Elec. Lett. 14 (1978) 728

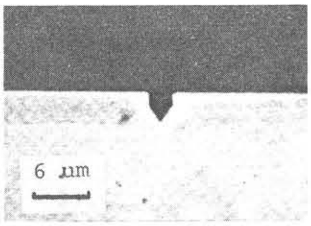

Fig. 1 The cross-sectional view of the groove etched by HCl.

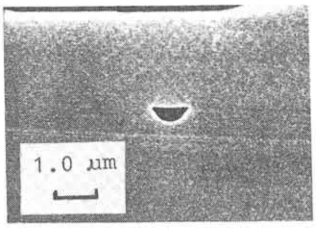

Fig. 2 The s.e.m. photograph of narrow active region.

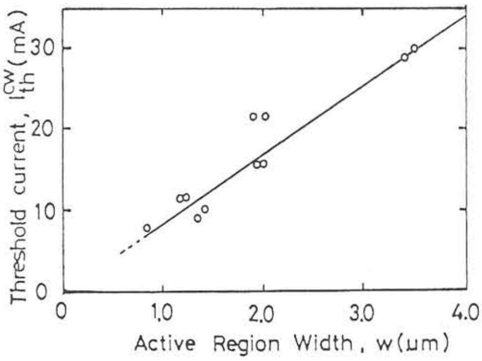

Fig. 3 The dependence of the threshold current I_{th}^{cw} at room temperature on the active region width w.

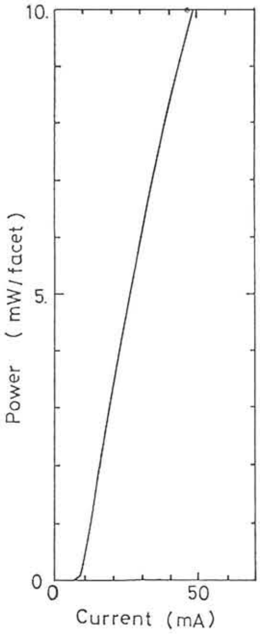

Fig. 4 The power-current characteristics of the low threshold current laser.