Analysis of Leakage Current in InGaAsP BH Lasers

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ABSTRACT

A self-consistent, two-dimensional device simulator for laser diodes is introduced and current leakage phenomena in InGaAsP BH (buried-heterostructure) lasers are analyzed with the device simulator. It is shown that minority carriers in blocking regions play a dominant role in determining current blocking capability in BH lasers.

A two-dimensional device simulator for laser diodes is a useful tool for a precise analysis of device characteristics of semiconductor lasers[1,2]. In this study, we discuss basic design principles for BH lasers with high current blocking capability.

Device modeling of laser diodes is based on five basic equations (Poisson's equation, current continuity equations for electrons and holes, wave equation and rate equation for photons) which are solved self-consistently[2].

Figure 1 shows current-flow distributions of BH laser in lasing oscillation. The thickness of the active layer is 0.15 μm and the emission wavelength is 1.3 μm. In this study, much attention has been focused on the relationship between leakage current and the thickness of n-type InP blocking layer in the middle of the buried region. In the simulated device structure, n-type InP blocking layer consists of two regions, which are referred to as BL1 and BL2. Their thicknesses are 0.3, 1.2 μm, and the width of BL1 is varied as a parameter from 1.0 to 3.5 μm. Simulation results indicate that injected current is thoroughly confined to the active region despite that 1.0-μm wide BL1 exists in the vicinity of the active region. On the other hand, current markedly spreads out into not only BL1 but also BL2 when the width of BL1 is 3.5 μm. These results indicate that the configuration of blocking layers adjacent to the active region exerts a significant influence on the current blocking capability of BH lasers.

In order to clarify the dominant factors determining the current blocking capability, we calculated minority carrier distribution in the buried region. Figure 2 compares hole density distributions along the dashed line in Fig. 1. When BL1 is 1.0 μm wide, minority carrier density is kept less than 10^{14} cm^{-3}. On the other hand, when BL1 is 3.5 μm wide, minority carrier density increases up to as high as 10^{16} cm^{-3}, which can lead to a marked increase in leakage current. It is, therefore, concluded that minority carrier density in blocking layers is one dominant factor in determining current blocking capability in BH lasers.

In summary, current leakage phenomena in InGaAsP BH lasers have been analyzed with the two-dimensional device simulator for laser diodes. It is found that minority carriers in buried regions dominate current blocking capability and it is necessary to lower the minority carrier density for an improvement of current confinement.

[1] T. Ohtoshi et al., 11th IEEE Laser Conf., Conf. Dig. pp. 210-211, 1988.
[2] S. Seki et al., 1988 IEDM Tech. Dig., pp. 323-326, 1988.

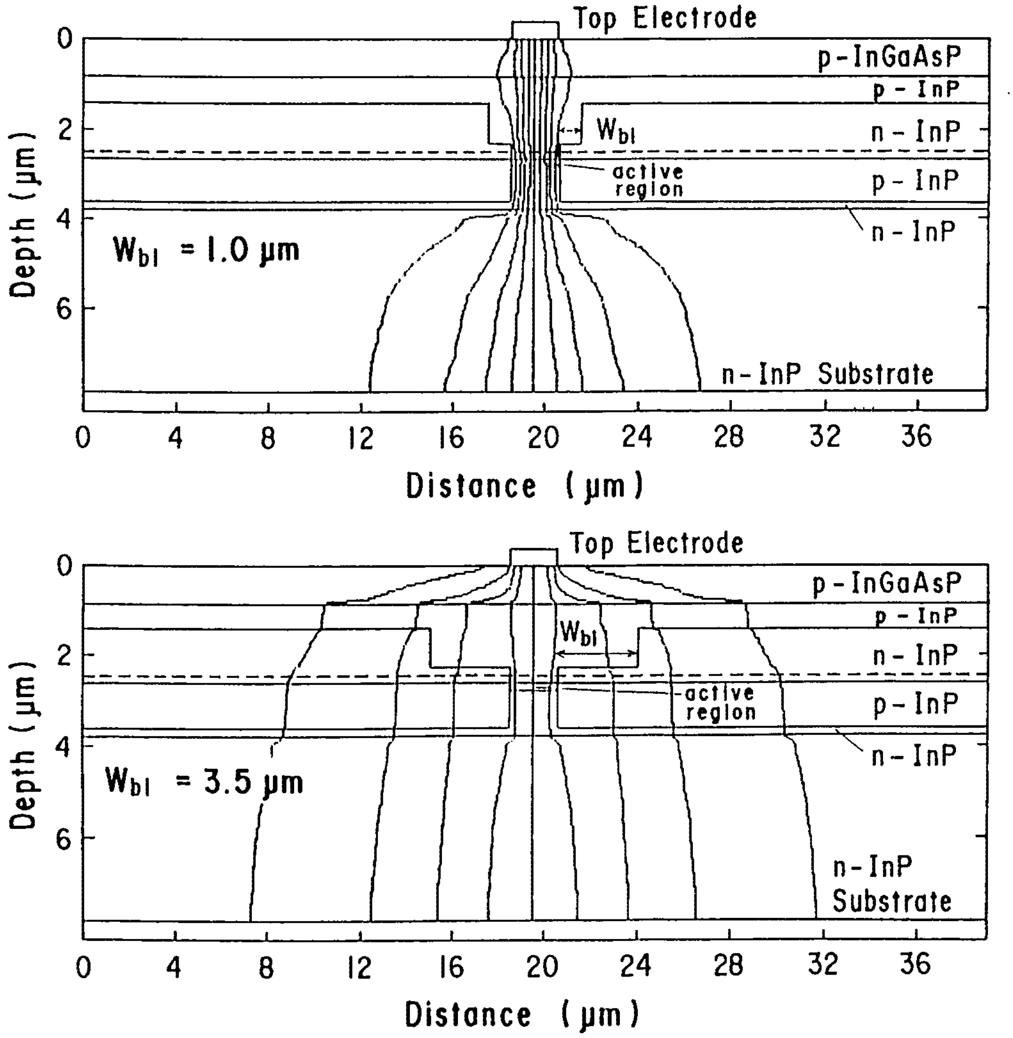

Fig. 1 Current flow distributions.

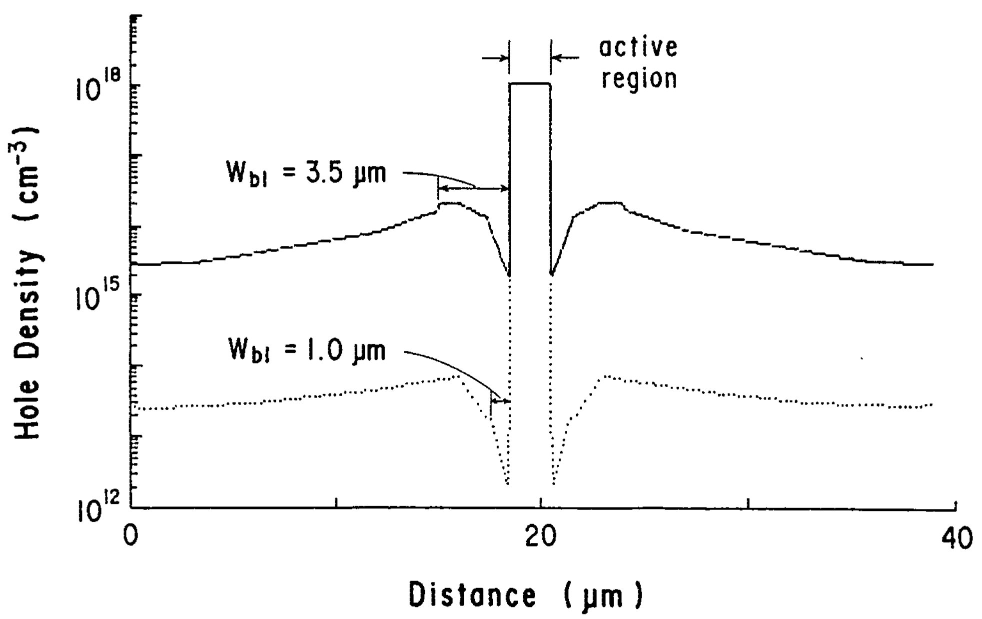

Fig. 2 Hole density distributions along the dashed line in Fig. 1.