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Buried-Heterostructure Injection Lasers

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Although various kinds of geometry have been proposed for lateral confinement of light and carriers in homo- and hetero-structure lasers, the undesired dimensional unbalance of the lasing aperture has not completely been avoided so far. In usual double-heterostructure (DH) injection lasers, the width is much greater than the thickness of the active region, its ratio amounting to 100 or more. The optical properties suffer from the dimensional unbalance. Though the lowest-order transverse modes perpendicular to the junction plane have been obtained reproducibly in DH lasers, the transverse modes parallel to the junction plane have been neither predictable nor reproducible. Moreover, the dimensional unbalance is not desirable when a DH laser is used as a light source in optical communication because of its low coupling efficiency into an optical fiber. Several geometries to reduce this unbalance ratio such as stripe-geometry,[1)] mesa-stripe-geometry,[2)] etc. have been proposed and have been studied. In spite of these efforts, the unbalance ratio remained still high. Reduction of this ratio below 10 will be possible if the width of the active region is narrowed below 5 μ. However, this narrowing is associated with the great increase of the threshold current density. This cannot be acceptable from the standpoint of cw operation and reliability of these lasers.

These disadvantages encountered in the conventional DH lasers can be overcome if the filamentary GaAs is completely buried in GaAlAs thus assuring light and carrier confinement in this extremely small GaAs active region. This structure has been born in minds of several workers. But the realization has not been reported until now. In this paper, we describe the fabrication and properties of the "buried-heterostructure" (BH) injection lasers in which the GaAs active regions are completely buried in the GaAlAs surrounding media. The typical fabrication procedures of BH lasers are composed of the four main steps as follows, 1) the LPE(liquid-phase-epitaxial) growth of the active region, 2) the mesa etching, 3) the secondary LPE growth, and finally 4) the selective diffusion. The BH lasers thus fabricated

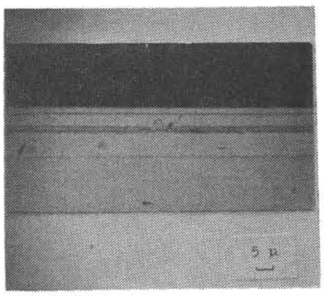

Fig. 1 The cross section of a BH laser.

do not suffer from the dimensional unbalance as was seen above in a variety of structures. Figure 1 shows an example of the buried active region. The cross section of the active region is triangular in this case. However, a trapezoidal shape is easier to obtain. Figure 2 shows (a) the spontaneous emission of a BH laser and (b) the lasing mode pattern (TE_{01}) of the same laser. The lowest-order transverse mode pattern (TE_{00}) has also been observed in lasers with smaller active regions. Figure 3 shows an example. When the active region is smaller than 1 μ square, the lowest-order transverse mode has usually been excited. Because it is not so difficult to fabricate a laser with its cross section smaller than 1 μ square, the BH laser is the first laser whose transverse mode can be predictable and reproducible. The stability of the mode pattern against the change in current has also been improved in BH lasers. The mode pattern has not changed its shape essentially by a change in excitation level of nearly one order of magnitude.

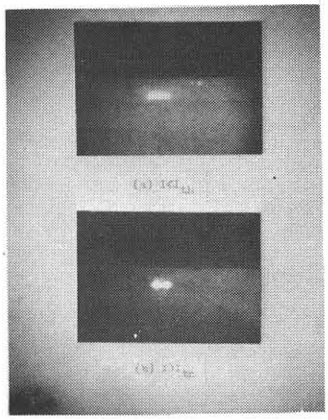

Fig. 2 The (a) spontaneous emission and (b) lasing mode pattern of a BH laser.

The threshold current density as low as 2.5 kA/cm^2 has been obtained in a laser with 2 μ cavity width. Because of the small active region and the low J_{th} in a BH laser, the lasing threshold has been greatly reduced. The threshold current as low as 15 mA has been obtained in room temperature pulsed operation in a laser with a 390 μ cavity length.

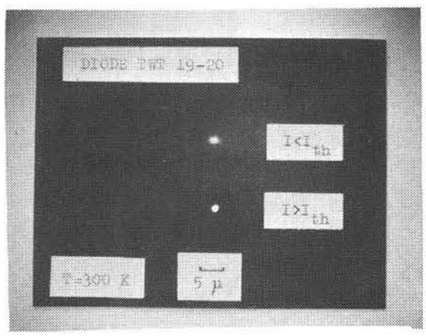

Fig. 3 The lowest-order transverse mode.

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