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A GaAlAs/GaAs Distributed Feedback Laser with Double-Channel Planar Buried Heterostructure

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Introduction

Recently, substantial progress has been achieved in the development of long-wavelength quaternary DFB Lasers, aiming at the long-haul optical communication systems. The research of short-wavelength DFB lasers, on the other hand, has been at a primitive stage after several pioneering works, and its progress [1-3] is expected in conjunction with optical information processing, optical measurements, and optical local area networks.

In this paper we describe fabrication and characteristics of the first GaAlAs/GaAs DFB laser with double-channel planar buried heterostructure (DC-PBH) [4]. A practical CW threshold current as low as 12mA, which is, to the best of our knowledge, much lower than ever reported, has been accomplished along with excellent single-longitudinal-mode property.

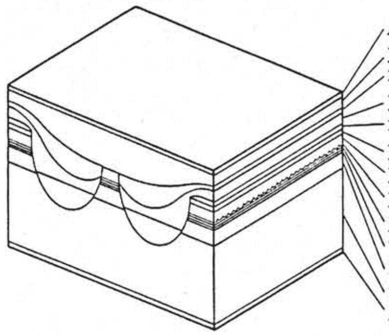

Fig.1. A schematic view of the GaAlAs/GaAs DFB DC-PBH LD.

Fabrication

Figure 1 shows a schematic drawing of the device prepared using three step liquid phase epitaxy (LPE). During the first LPE, lower cladding (1μm-thick), active (0.15μm), carrier-blocking (0.15μm), and waveguiding (0.2μm) layers were successively grown on an Si-doped (100) $n^+ - GaAs$ substrate. Third-order diffraction gratings, of which the period was 3600Å, were delineated on the waveguiding layer by the spherical-wave holographic method [5] using an argon ion laser and wet etching. The second LPE was then performed to grow upper cladding (0.7μm-thick), and cap (0.3μm) layers on top of the gratings.

A pair of channels were formed by a non-preferential etchant down to the substrate, thus leaving a 1.5μm-wide mesa region at the center. In the third LPE process, current blocking and confining layers were grown on the whole surface, except on the mesa top. Finally, these layers were completely embedded by a $p^+ - GaAs$ cap layer to yield a flat surface. The wafer was then cleaved into each device. The cavity length ranged between 150 and 250μm. No attempt was made to control the cleaved-facet reflectivity, such as scratching or anti-reflection coating.

Device Characteristics

Illustrated in Fig.2(a) is an example of light-current characteristics under room-temperature CW operation. The threshold current of 12mA in the figure is, to the best of our knowledge, the lowest value as a short-wavelength DFB laser.

The oscillation spectra at several injection levels are shown in Fig.2(b). As observed in the spectrum at I_{th}, the oscillation took place at the edge of the stop band on the longer-wavelength side. The single longitudinal mode was maintained at any injection level. In this case, asymmetry in the phase of the facet reflectivity presumably removed the threshold degeneracy of the two modes on the edge of the stop band, thus yielding excellent single-longitudinal-mode characteristics. However, two-mode oscillation was sometimes observed in other devices, where the phase of the facet

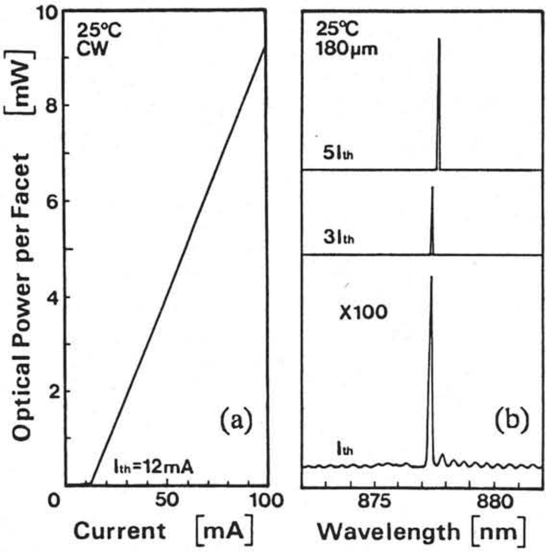

Fig.2. (a) Light output vs. injection current characteristics at room temperature, (b) Oscillation spectra at several injection levels

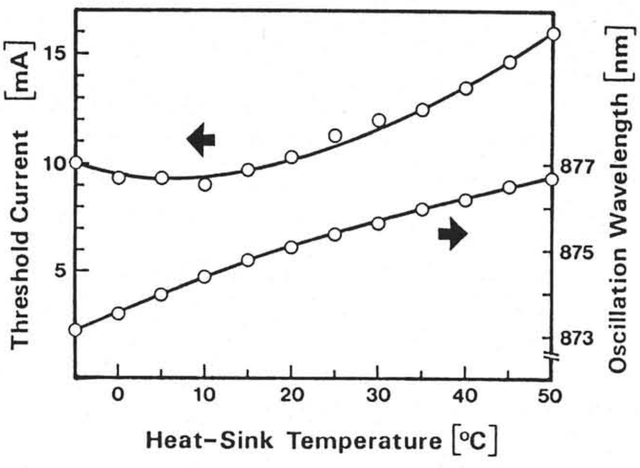

Fig.3. Dependence of the lasing wavelength and the threshold current on heat-sink temperature.

reflectivity may differ from the above example. For improving the yield of obtaining single-longitudinal-mode operation, the stripe-width modulation scheme [6] should be introduced to this structure.

Temperature dependence of threshold current and lasing wavelength was measured as plotted in Fig.3. The minimum threshold current was 9mA at 10°C. The temperature range within which the device lased in a single longitudinal mode was over 60 degrees. The temperature coefficient of the oscillation wavelength was evaluated as approximately 0.65Å/K, which is consistent with the temperature coefficient of refractive index of GaAs itself.

This device suggests that the single-mode stability of DFB lasers will benefit not only the long-haul optical communications but also the other fields where shorter wavelength is demanded.

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