Extended Abstracts of the 1991 International Conference on Solid State Devices and Materials, Yokohama, 1991, pp. 745-746

Fabrication of InGaAsP/InP Gain-Coupled Distributed Feedback Laser

T.Inoue, S.Nakajima, T.Oki, H.Iwaoka, Y.Nakano*, and K.Tada*

Optical Measurement Technology Development Co., Ltd.
2-11-13 Naka-cho, Musashino-shi, Tokyo, 180, Japan
Phone:(0422)54-3336 Facsimile:(0422)55-8080

**Department of Electronic Engineering, University of Tokyo*
7-3-1 Hongo, Bunkyo-ku, Tokyo, 113, Japan
Phone:(03)3812-2111 Facsimile:(03)3818-5706

We have been reporting on AlGaAs/GaAs gain-coupled (GC) distributed feedback (DFB) lasers with a corrugated active layer. These lasers have several advantages such as excellent single longitudinal mode properties without phase shifting structures[1-2], immunity to facet reflection[3], resistance to external optical feedback[4], and the capability of generating single mode short optical pulses with low chirping[5]. These advantages are also beneficial in InGaAsP/InP DFB lasers. Here, we describe the realization of the InGaAsP/InP GC DFB laser with a corrugated active layer using reactive ion etching (RIE) and organometallic vapor phase epitaxy (OMVPE). The devices exhibit excellent single longitudinal mode CW oscillation.

A schematic longitudinal cross section of the device structure is shown in Fig. 1. Its corrugated active layer produces periodic perturbation in the modal gain coefficient. After the first OMVPE step, a deep rectangular grating was engraved on the InGaAsP(λ_g=1.3 μm) pattern-providing layer using RIE. A first-order diffraction grating with a 236 nm period was formed by holographic exposure, and the resist grating itself was used for the RIE mask. The RIE conditions are shown in Table I. The grating surface was slightly wet-etched to remove the RIE damage before regrowth. In the regrowth step, thin InP buffer layer, InGaAsP(λ_g=1.55 μm) active layer, and InP cladding layer were successively grown. The growth temperature of 650 °C was used with the heating up time being 3 min, in order to avoid deformation and degradation of the grating surface. A cross-sectional view of the epitaxial layers is shown in Fig. 2. The corrugation height of the pattern-providing layer and the active layer are 120 nm and 80 nm, respectively.

The epitaxial wafer was made into a planar buried heterostructure (PBH) stripe configuration with 1 μm width and 200 μm length. Both facets were left as cleaved. CW lasing characteristics are shown in Fig. 3. A threshold current of 17 mA was achieved. Neither the grating formation on the active layer nor the RIE procedure affected the emission efficiency of the active layer. An oscillation spectrum measured at 1 mW is illustrated in Fig. 4. No stop band is observed, and the side mode suppression ratio is measured as 35 dB. The device maintains the same DFB mode oscillation within a temperature range of 10~70 °C and the temperature coefficient of the lasing wavelength in this range is 0.074 nm/K.

In summary, we have, for the first time, realized a 1.55 μm CW-operable GC DFB laser. The advantages of the gain coupling will be of great help in long-distance optical communication applications.

References

[1] Y.Luo, Y.Nakano, K.Tada, T.Inoue, H.Hosomatsu, and H.Iwaoka, Appl. Phys. Lett. **56**, 1620 (1990).
[2] Y.Luo, Y.Nakano, K.Ikeda, K.Tada, T.Inoue, H.Hosomatsu, and H.Iwaoka, Conference Digest, 12th IEEE International Semiconductor Laser Conference, E-6, Davos, Sept. 1990.
[3] Y.Nakano, Y.Luo, and K.Tada, Appl. Phys. Lett. **55**, 1606 (1989).
[4] Y.Nakano, Y.Deguchi, K.Ikeda, Y.Luo, and K.Tada, Conference Digest, 12th IEEE International Semiconductor Laser Conference, E-7, Davos, Sept. 1990.
[5] Y.Luo, R.Takahashi, Y.Nakano, K.Tada, T.Kamiya, H.Hosomatsu, and H.Iwaoka, Technical Digest, Conference on Lasers and Electro-Optics, CWK-5, Baltimore, May 1991.

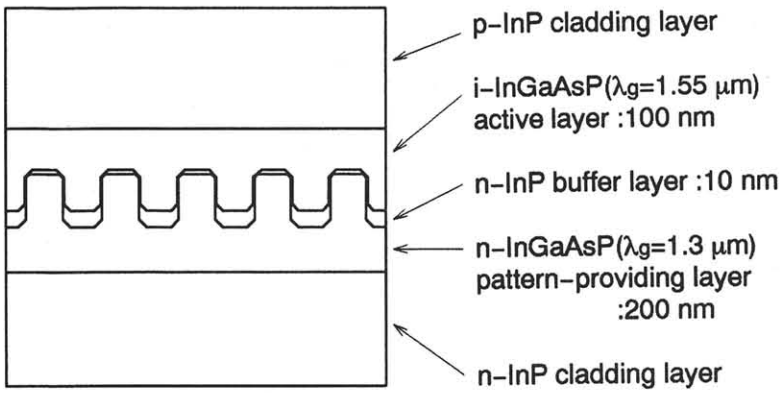

Fig. 1 Schematic longitudinal cross section of the gain-coupled DFB laser with a corrugated active layer.

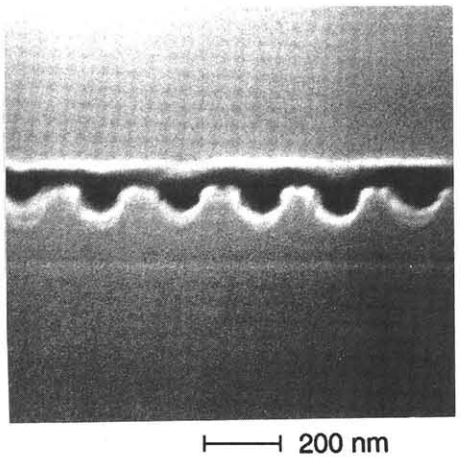

Fig. 2 Scanning electron micrograph showing the longitudinal cross section of the epitaxial layers.

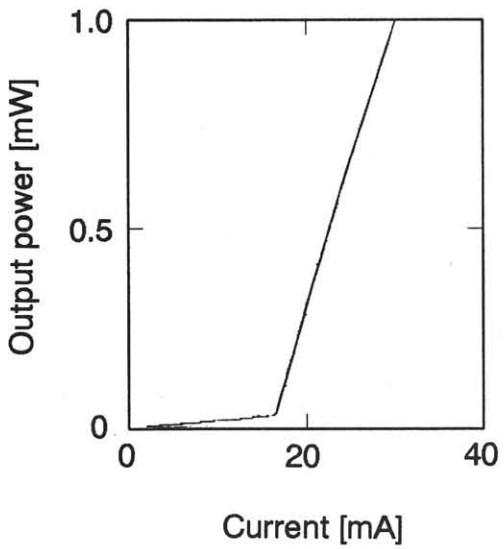

Fig. 3 CW light output vs. injection current characteristics.

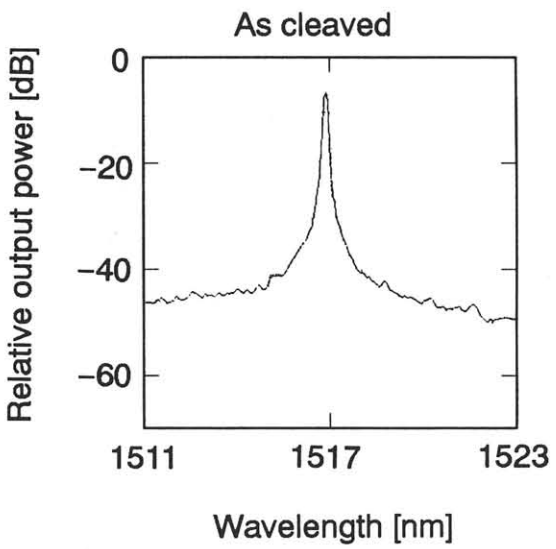

Fig. 4 Lasing spectrum at 1 mW.

Table I Conditions of the reactive ion etching

apparatus	: rf planar diode RIE system (ANELVA EVP17485)
cathode electrode	: 150 mm in diameter
reactant gas	: 6.3% C_2H_6/H_2 + Ar
total pressure	: 5.0 Pa
rf power density	: 1.4 W/cm^2 (13.56MHz)
etching rate	: 20 nm/min
etching mask	: photoresist grating (pitch 236 nm) prepared by holographic exposure