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B-7-3 Room Temperature Operation of Distributed Feedback Diode Laser with Separate Optical and Carrier Confinement

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A marked progress in the distributed feedback (DFB) diode laser has been achieved in the last one year. The laser oscillation has been demonstrated in GaAs-GaAlAs double-hetero (DH) structure lasers[1),2)] and single-heterostructure lasers[3)], in which the optical feedback for the laser oscillation was provided by a corrugated interface between the p-GaAs active layer and the outer p-GaAlAs layer. In these experiments, however, oscillation has been limited in the temperature range below about 150 K. It was found that the fabrication of the corrugation on the active layer introduced the interface recombination centers which increased the threshold current density at higher temperatures.

One of the solution to this problem will be to use a separate optical and carrier confinement hetero (SCH) structure in which the corrugated interface for optical feedback was separated from the active layer. In the present work, we describe the preparation and the resulting room-temperature operation of such a SCH structure DFB diode laser.

A cross-sectional view of the SCH structure DFB laser is shown in Fig. 2, where carriers are confined to the p-GaAs active layer while the light extends to the p-$Ga_{0.83}Al_{0.17}As$ layer and the corrugated p-$Ga_{0.93}Al_{0.07}As$ layer.

In the fabrication of the SCH structure DFB laser, the layers from the n-$Ga_{0.7}Al_{0.3}As$ to the p-$Ga_{0.93}Al_{0.07}As$ were grown successively by liquid phase epitaxy (LPE). Next, surface corrugations were made on the p-$Ga_{0.93}Al_{0.07}As$ layer by chemical etching through a photoresist mask produced by holographic photolithogtaphy. Finally, the p-$Ga_{0.7}Al_{0.3}As$ and p-GaAs layers were grown on the corrugated surface by LPE.

The diode had a mesa-stripe geometry so that the injection could be limited to a rectangular region[1)].

The lasing characteristics were investigated in a temperature range from 80 K to 340 K under pulsed operation.

At 300 K, the lowest

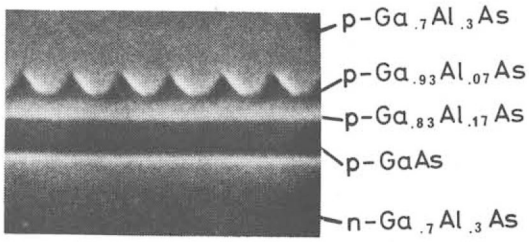

Fig. 1 A SEM photograph of the SCH structure DFB laser. The period is 3700 Å.

threshold current density was 3 KA/cm^2 for Λ=3770 Å and L = 900 μm, where Λ is the period of the corrugation and L is the length of the excited region. This is about 1/30 of the threshold current density estimated in the DH structure DFB lasers by extrapolation.

The emission spectra of a typical SCH structure DFB laser is shown in Fig. 2. The diode lased in only one single longitudinal mode with a spectral half width of less than 0.5 Å. At 260 K, we observed two peaks, the separation of which was 67 Å. From the theoretical analysis and observation of the radiation pattern, they were assigned to be transverse modes perpendicular to the junction plane. At 300 K, the diode lased in the lowest transverse mode (m = 0) with a peak wavelength of 8829 Å. The selectivity of the longitudinal mode in the DFB laser suggests that there may be no self-induced pulsation caused by mutual coupling of the longitudinal modes. The wavelength of each transverse mode had a temperature dependence of 0.6 Å/deg, which is about 1/6 that of Fabry-Perot Lasers at ~ 300 K.

Intensity distribution of the lasing light in the corrugated waveguide was investigated along the direction of light propagation by measuring the intensity of the scattered light. A distribution having a maximum near the center of the excited region was observed in contrast to the case of Fabry-Perot lasers. The optical coupling constant was estimated to be about 50 cm^{-1} for the diode.

In conclusion, GaAs-GaAlAs DFB diode lasers with a SCH structure were operated at temperatures up to 340 K under pulsed bias and the predicted features of the DFB laser were demonstrated experimentally.

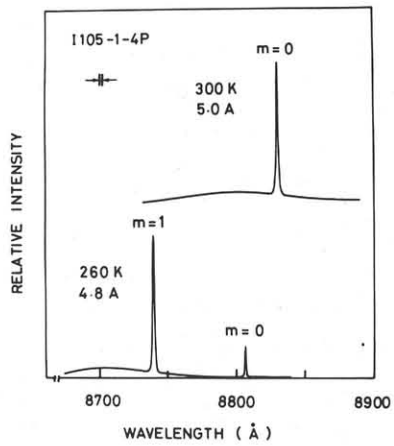

Fig. 2 The lasing spectra of a SCH structure DFB laser. 'm' is the transverse mode number.

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