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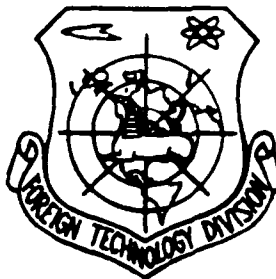
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DEVELOPMENT OF LOW-THRESHOLD VALUE,
HIGH-POWER SEMICONDUCTOR LASER

by

Li Yudong, Zhu Donghai, et al.



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DEVELOPMENT OF LOW-THRESHOLD VALUE, HIGH-POWER
SEMICONDUCTOR LASER

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Abstract: The paper presents the concept and experimental results of a novel large optical-cavity structure semiconductor laser.

Key words: channeled substrate, twin-ridge substrate, three-segmented cavity laser.

In recent years, the stable single-mode, high-power semiconductor laser advanced markedly in research to satisfy requirements for practical applications in data processing with optical disk, laser printing and long-distance communications. For GaAlAs/GaAs lasers, one of the main causes of limited improvements in power output is the optical catastrophic breakdown [1] at the cavity surface. By expanding the dimensions of near-field beam spots [2] to reduce the density of photon flux at the cavity, or to convert the cavity surface into a transparent zone [3] not absorbing light, all these measures are important in raising the power output. However, lowering the threshold-value current and decreased leakage current are also advantageous for higher power output of the device.

Based on the foregoing principles, the authors designed and made a novel structure laser with relatively better results.

1. Structural design and manufacturing technique

1.1. Equipment layout. Fig. 1 shows a three-segmented cavity laser composed of a twin-ridge substrate laser with connection at both ends to a channeled-substrate laser. The authors call this device a channeled twin-ridge substrate structure laser. The cavity length L of the twin-ridge part is much greater than the cavity length L_c of the channeled part. The design concept and the features of this device are as follows:

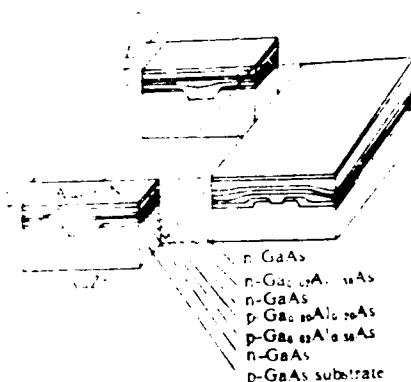


Fig. 1. Schematic diagram of channeled twin-ridge substrate structure laser

(1) Utilizing the features of different structures of the channeled and twin-ridge substrate, as well as the liquid phase epitaxy, simultaneous growth is achieved after relatively thick waveguide layer in the channeled zone, and a relatively thin waveguide layer in the twin-ridge zone. This arrangement forms a light transmission window in the channeled-substrate zone, and owing to the existence of the thin waveguide layer in the twin-ridge, the threshold-value current of the device is lowered.

(2) By the use of a current barrier layer of the reverse-direction p-n junction, the lateral-direction current limitation is increased, and the current injection is made higher.

(3) Generated by the lateral-direction light absorption and the variation of thicknesses of the source layer and waveguide layer, the weak refractive index leads to a limitation, thus stabilizing the lateral-direction optical field.

1.2. Manufacturing technique: First on the p^+ -GaAs substrate along the crystal direction (100), along the [011] direction sculpture a graph with alternation of terraced and planar surfaces, then grow the n^+ -GaAs current-barrier layer. By utilizing the strip-shaped optically carved block to sculpture the strip-shaped current channel on the primary epitaxial strip, thus a channeled substrate zone and twin-ridge substrate zone are formed. The depth of these zones can be sculptured through the current barrier layer. After chemical washing, the secondary epitaxial growth is conducted to grow in sequence the p -Ga_{0.62}Al_{0.38}As limitation layer, p -Ga_{0.80}Al_{0.20}As waveguide layer, n -GaAs source layer, n -Ga_{0.62}Al_{0.38}As limitation layer and n -GaAs contact layer. The prepared epitaxial chip goes through the work steps of evaporated electrode, alloy doping, cleavage and assembly to finally yield a device for measurement and testing.

2. Device performance and conclusions

The developed channeled twin-ridge substrate laser can continuously operate at room temperature; its direct-current (dc) average threshold-value current is 50 to 90mA, and the lowest is 40mA. Fig. 2 shows the performance curves of optical power and the injection current of several devices. It is apparent that the linear output can be maintained at about 30mW; and the maximum power can be as high as 42mW. Figs. 3 and 4 show the

site intensity distribution of the lateral-direction near-field of No. F7 laser, as well as its P-I curve and the optical spectrum characteristic curve. In the figure, the five points (a, b, c, d, e) of the P-I curve correspond to the current values of five optical spectra. In addition, the relatively high single-surface external differential quantum efficiency thus obtained is higher than 40%; better results are also obtained in temperature stability of the single longitudinal mode.

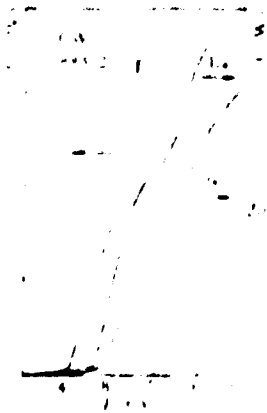


Fig. 2. P-I characteristic curves

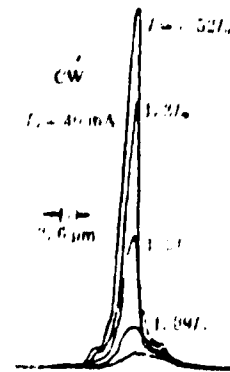


Fig. 3. Distribution of lateral-direction optical field of F7 laser

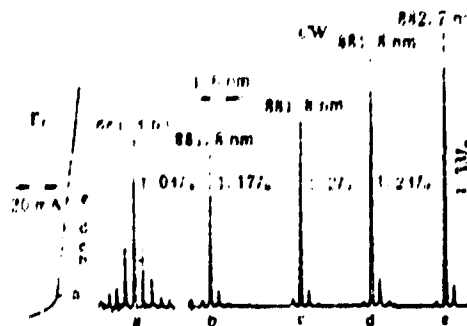


Fig. 4. P-I characteristic curves of F7 device and optical spectra at points a, b, c, d, e

As shown by the experimental results, this type of laser can easily operate under conditions of low threshold-value current and high power; its characteristics of the lateral and

longitudinal modes are also relatively good. This laser is a promising and novel device.

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