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Novel High Power Quantum Well Lasers With Integrated Passive Waveguide*

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Abstract　A kind of novel high power quantum well laser with an integrated passive waveguide has been designed and fabricated to prevent the high photo density region from concentrating in the transverse waveguide center in the diode laser cavity. The new structure has a smooth near-field profile of the fundamental transverse mode in the co-waveguide center. According to the results of the 100μm-wide and 800μm-long lasers, we can achieve that the light output power is 2.6W at wavelength of 980nm (at 19℃ and under CW operating condition). The threshold current density to be 320A/cm^2, the slope efficiency to be 0.9W/A and the resistance in series to be 0.15Ω can be measured through the facet-coated devices with LR/HR being 0.1/0.95.

PACC: 4225P, 4260B, 4260C

The high power semiconductor diode lasers are of great benefit and have been developed[1~5] because they have wide application in many fields such as pump solid-state lasers, Er-doped optical fiber amplifiers, medical therapy devices and so on. The light output power to increase more in the high power laser diode is limited by heating and the catastrophic optical mirror damage (COMD).[3,6]

In this paper, we first introduce the structure of the novel high-power strained-layer quantum well laser with an integrated passive wave-guide (IPW). The active sub-waveguide of the asymmetric seperate confinement heterojunction (SCH) quantum wells is coupled the passive one of the asymmetric four-layered slab waveguide through the coupling layer——a co-cladding layer. The lasing mode index in this structure is equal to the material refractive index in the coupling layer, so that the near-field profile has a horizontal distribution in the coupling layer. Compared with the usual structure, the field cross-section of the laser cavity will increase more.

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Figure 1 is a diagrammatic sketch of the refractive index (*a*) and the calculated results according to the transverse near-field distribution (*b*) and the vertical far-field pattern (c) for the new structure. The active sub-waveguide and passive one are coupled through the undoped coupling-layer of 500nm's thick. The calculated light confinement factors of the quantum well, the coupling layer and the passive waveguide are 1.7%, 52.1% and 15.1% respectively. The theoretical vertical far-field angle is 33 °(FWHM).

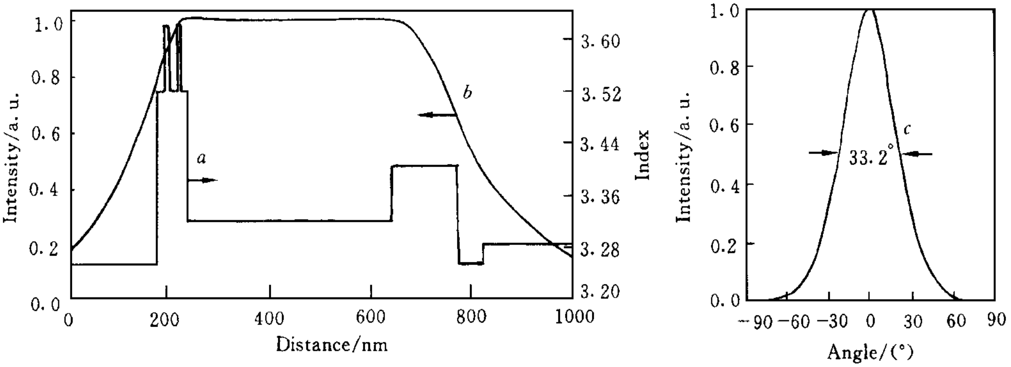

FIG. 1 Diagram of refractive index (*a*) and the calculated results of transverse near-field distribution (*b*) and vertical far-field pattern (*c*).

The structure of the InGaAs/GaAs/AlGaAs strained-layer quantum-well laser with a passive waveguide has been grown by low-pressure metal-organic chemical vapor deposition (LP-MOCVD) on the (100) oriented Si-doped GaAs substrate with the doping concentration being 1~2×10^{18}cm^{-3} in the Aixtron A200 system. They consist of (1) a GaAs buffer layer with Si-doped 1×10^{18}cm^{-3}, (2) a $Al_{0.4}Ga_{0.6}As$ lower cladding layer with Si-doped 1×10^{18}cm^{-3}, (3) a $Al_{0.45}Ga_{0.55}As$ cladding layer with Si-doped 5×10^{17}cm^{-3}, (4) a $Al_{0.2}Ga_{0.8}As$ passive waveguide layer with light Si-doped, (5) an undoped $Al_{0.338}Ga_{0.662}As$ coupling-layer, (6) three undoped GaAs barriers, (7) two undoped $In_{0.2}Ga_{0.8}As$ strained quantum wells, (8) a $Al_{0.45}Ga_{0.55}As$ upper cladding layer with Zn-doped 1×10^{18}cm^{-3}, (9) a GaAs top layer with Zn-doped 4×10^{18}cm^{-3}, (10) a GaAs contact layer with Zn-doped greater then 2×10^{19}cm^{-3}.

The TiPtAu strip contacts of 100μm's wide have been fabricated on the p-side of the wafer by standard photolithography techniques. Then the wafers is thinned to 100μm, while the AuGeNi/Au is deposited on the n-side. Broad-stripe (100μm-wide) lasers are fabricated, coated (LR/HR, 0.1/0.95) and mounted junction-side down on copper heatsinks.

The measured threshold of the current densities at a cavity length of 800μm is 320A/cm^2. Figure 2 shows a light output power, voltage and wallplug efficiency versus drive current characteristics measured under CW operating condition at room temperature of 19℃. The light output power of the device reaches 2.6W at the drive current to be 3.5A.

The slope efficiency of 0.9W/A is reached. The maximum wallplug efficiency of 40% could be reached with the resistance in series to be 0.2Ω (the best to be 0.15Ω). Figure 3 shows the parallel and vertical far-field patterns of new structure. The vertical beam divergence is 32°, which is in good agreement with the theoretical results. The lasing spectrum characteristics with wavelength of 980nm are shown in Fig. 4.

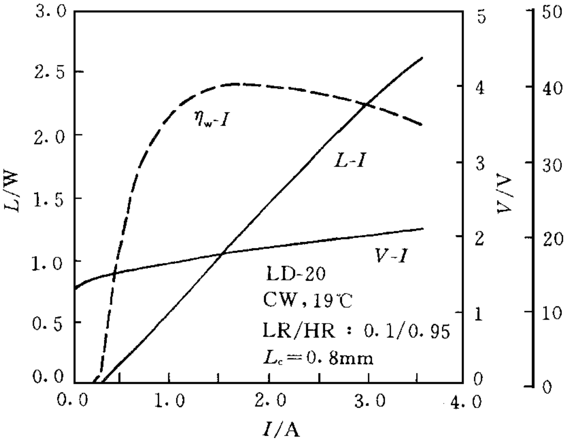

FIG. 2 Light output power, voltage and wallplug efficiency characteristics versus drive current

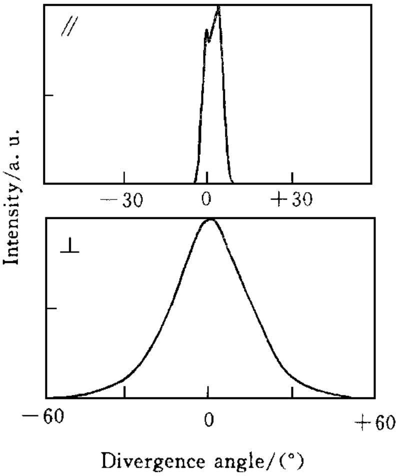

FIG. 3 Parallel and vertical far-field patterns

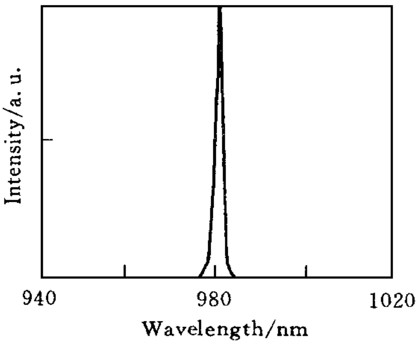

FIG. 4 Lasing spectrum characteristic

We can design the active region of quantum wells to lay near the P-AlGaAs cladding layer, and at the same time make the evanescent field in the n-cladding layer extend more than that in the p-cladding layer in order to reduce the thermal resistance, the series resistance and the free carrier loss in the cladding layers. It is believed that the absorption loss of the free electron is less than that of the free hole as well as the mobility of electron is about ten times higher than that of the hole. The high order transverse modes are repressed by the asymmetric waveguide structure. The n-side light field could spread longer distance to reduce the divergence angle of the transverse light beam.

We have demonstrated the novel structure of high power strained-layer quantum-well lasers with an integrated passive waveguide. The light output power of 2.6W, the threshold current density of 320A/cm^2 and slope efficiency of 0.9W/A could be reached when the resistance in series is 0.15Ω. We can optimize the parameters of material and structure in these novel quantum well lasers in order to improve the device performance.

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