EFFECT OF ASYMMETRIC BARRIER LAYERS IN THE WAVEGUIDE REGION ON THE TEMPERATURE STABILITY OF QUANTUM-WELL LASERS


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An important parameter of diode lasers is the characteristic temperature $T_0$, which describes the temperature sensitivity of the threshold current. High $T_0$ is required for stable operation under variable ambient conditions as well as for minimization of self-heating effects at high operating powers. Ideally, the room-temperature value of $T_0$ in a quantum well (QW) laser can be as high as 300 K. However, in the conventional QW lasers, the electron-hole recombination occurs not only in QWs but also outside the active region, which may significantly increase the threshold current and reduce its temperature stability. Electron-hole recombination in the optical confinement layer (OCL) is particularly important in lasers with broad OCL, which are used for high power operation and in lasers with small localization energy of carriers in a QW.

The parasitic recombination in the OCL can be suppressed in a laser structure with two asymmetric barrier layers (ABLs) (one on each side of the active region) as it has been proposed in Ref. 2. In the ABL laser, while the electrons (holes) injected from the $n$-cladding ($p$-cladding) layer easily pass over the $n$-side ($p$-side) ABL on their way to the QW, the holes (electrons) injected from the $p$-cladding ($n$-cladding) layer ideally should not pass over or tunnel through that ABL. Hence, there will be ideally no holes (electrons) in the part of the OCL confined between the $n$-side ($p$-side) ABL and the $n$-cladding ($p$-cladding) layer. As a result, the recombination current in the ABL laser will be purely due to recombination in the QW and the characteristic temperature will be the characteristic temperature of an ideal QW laser.

It has been shown recently that the required asymmetry of electron and hole energy barriers can be achieved in GaAs-based laser structures. However, there has been no experimental proof of the ABL laser concept up to now.

In the present work we have fabricated and tested a QW laser with ABLs and have compared it with a conventional reference QW (CQW) laser (laser without ABLs). Compared to the CQW laser, our ABL QW laser demonstrated reduced threshold current and increased characteristic temperature. The largest difference in $T_0$ values is 44 K (143 K in the ABL laser vs. 99 K in the CQW laser) and it was obtained at 20 °C. In addition, the ABL laser was characterized by lower and less temperature-sensitive internal optical loss. Factors affecting the characteristic temperature and its dependence on the optical loss were analyzed. It was shown that the inclusion of ABLs results in weakening of the temperature dependences of the transparency current density and the gain saturation parameter and, consequently, leads to higher characteristic temperatures.

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