Optical characterization of GaAsSb/GaAs type-II quantum well with an adjacent InAs quantum-dot layer composite structures

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Due to the type-II band alignment, the electron and hole in a GaAsSb/GaAs strained quantum well (QW) are spatially separated. This configuration leads to the fundamental transition energy of QW being lower than the band gaps of the barrier and well. This is a great advantage in application to long wavelength lasers [1]. However, the spatial separation of the electron and hole wavefunctions results in a low optical matrix element which leads to high threshold current density in GaAsSb/GaAs QW 1asers. One way to increase the matrix element is to enhance the confinement of the active medium. A composite structure consisting of a GaAsSb/GaAs QW and an adjacent InAs/GaAs self-assembled quantum dots (QDs) has been proposed to improve the performance of the type-II laser diodes [2]. In this composite structure, GaAsSb QW and a GaAs spacer layer were grown beneath InAs QDs. Since the strain exerted by InAs QDs on their bottom is tensile below the dots and compressive under the edge of the dots, the band diagram of the GaAs spacer and GaAsSb QW are modulated to form potential wells in the growth plane. As a result, both electrons and holes are trapped in the potential wells induced InAs QDs. Along the growth direction, the type-II GaAsSb/GaAs heterostructure provides the confinement of the third dimension.

In this work, a detailed optical characterization of this composite structure was carried out by using by using surface photovoltage spectroscopy (SPS) and photoluminescence (PL) techniques. The room temperature SPS spectra exhibit the features originated from QDs, QW, wetting layer and GaAs cap-layer/barrier. The low-temperature PL band of the modulated potential wells in GaAsSb QW, resulting from the tensile strain exerted by the InAs QD stressor, showing a giant redshift as compared with the GaAsSb QW control sample at low excitation level. At higher temperature, the thermalization of carriers in QDs enhances the fluctuation of the potential wells, which provides extra quantum confinement for the carriers and enhances the luminescence intensity. This effect can be used to improve the performance of type-II GaAsSb/GaAs QW lasers.

[1] N. N. Ledentsov, M. Grundmann, F. Heinrichsdorff, D. Bimberg, V. M. Ustinov, A. E. Zhukov, M. V. Maximov, Zh. I. Alferov, and J. A. Lott, IEEE J. Sel. Top. Quantum Electron. 6, 439 (2000).
[2] Y. R. Lin, H. H. Lin, and J. H. Chu, Electron. Lett. 45, 682 (2009).

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