Epitaksinių InGaAs kvantinių strypelių optiniai tyrimai

Optical investigation of epitaxial InGaAs quantum rods

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Novel epitaxial nanostructures, quantum rods (QRs), have gained interest in fundamental and experimental physics due to potential applications in optoelectronics. QRs consists of vertically elongated InGaAs quantum dots (QDs) immersed in the shallower InGaAs/GaAs quantum well (QW). The combined 0D and 2D carrier confinement in QRs leads to a variety of new properties with respect to regular QDs, showing features of the pure QD, pure QW and mixed electronic states. Additionally, bound states can also appear within QW continuum states [1]. Therefore, to reveal interesting optical and carrier dynamic properties [2] QRs should be spectroscopically explored in more detail.

In this report, the temperature-dependent (3–300 K) optical investigation of different (0.25–4.1) aspect ratio (AR) InGaAs QRs is presented. The complementary spectroscopic techniques of photoluminescence (PL), PL excitation (PLE) and photoreflectance (PR) (Fig. 1), supported by the calculations within 8-band **kp** model (Fig. 2), has given an insight into the physical properties of the QR structures studied.

Photomodulation (PR) technique has been used to determine the band structure of QR/QW complex system (Fig. 1). The experimental results were then verified by the calculations of energy levels and wavefunctions of realistic 3D model, taking into account strain and piezoeffect. Temperature and excitation power dependent variation of interband optical transitions related to In-rich InGaAs QRs and the surrounding InGaAs QW are revealed and discussed. In particular, PL spectra show a QR height-dependent blueshift with increasing excitation power. This blueshift is discussed in terms of the phase-space filling effects in the QRs, according to calculated optical transition intensities (Fig. 2). The analysis of thermal quenching of emission intensity yield two activation energies, assigned to low and high temperature ranges. It is supposed that thermal escape of carriers from InGaAs QRs to the surrounding InGaAs QW is not very efficient due to a strong reverse process. Moreover, the possible channels of the carrier transfer were established from PLE investigations, performed at different temperatures.

Keywords: InGaAs quantum rods, interband transitions, photoreflectance, photoluminescence.

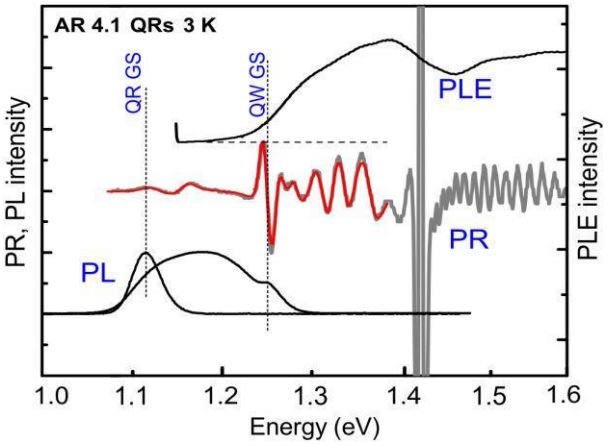

Fig. 1 Low- and high-excitation photoluminescence (PL), photoreflectance (PR) and photoluminescence excitation (PLE) spectra of high AR (4.1) InGaAs QR structure. Measurements were carried out at 3 K.

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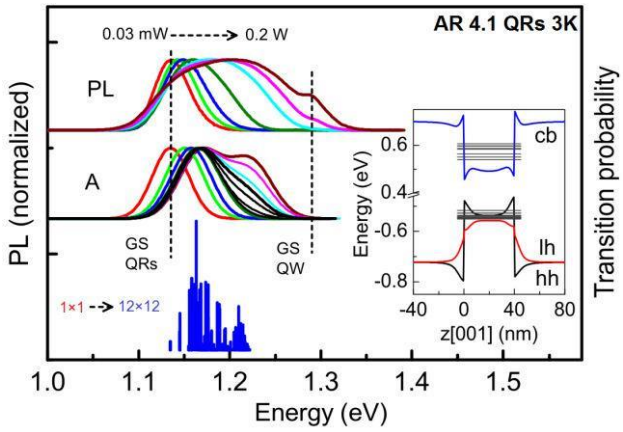

Fig. 2 Low temperature normalized PL spectra (excitation: 0.03–200 mW) and normalized intensity of calculated optical transitions (A), gradually including electronic states from 1×1 to 12×12. The bars indicate QR optical transition energies and intensities calculated within strain-dependent 8-band **kp** model.

References

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