In/Ga intermixture in InAs QD asymmetric DWELL structures

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The photoluminescence and its temperature dependence have been investigated for InAs quantum dots embedded in asymmetric GaAs/$In_xGa_{1-x}As$/$In_{0.15}Ga_{0.85}As$/GaAs quantum wells (DWELL structures) as a function of the indium content x (x=0.10-0.25) in the capping $In_xGa_{1-x}As$ layer. Photoluminescence (PL) enhancement and red shift of the QD ground state peak position have been observed as x increases from 0.10 to 0.15. Significant degradation of the PL intensity is accompanied by a blue shift of the PL peak position and PL band broadening when x = 0.20 or 0.25.

The fitting procedure was applied on the base of the Varshni analysis to the PL peak shift versus temperature in different asymmetric DWELL structures. It was revealed that only in the DWELL structure with x = 0.15 the shift of quantum dot PL peak position versus temperature has been realized by the same way as the band gap shrinks with temperature in the bulk InAs. In DWELL structures with x = 0.10, 0.20 and 0.25 the parameters of the thermal shift of QD emission peaks were different from the bulk InAs band gap shrinkage and corresponded to the $In_xGa_{1-x}As$ band gap. Thus it was shown that for mentioned DWELL structures (x = 0.10, 0.20 and 0.25) the process of In/Ga intermixture in QD material is essential.

Note the In content increasing in the capping InGaAs layer results in the lattice mismatch and stress decreasing at the QD InAs/InGaAs interface and, simultaneously, the lattice mismatch and stress increasing at the QW InGaAs/GaAs spacer interface area between InAs QDs. The estimation of the elastic energy revealed that the capping layer composition with x=0.15 corresponds to the minimum value of elastic energy in studied DWELL structures. The last fact is the reason as well of higher quality of this DWELL structure that manifested itself by the higher QD PL intensity, and lower a full width at half maximum of PL bands. The localization of non-radiative defects in studied asymmetric DWELL structures are discussed.

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