Type II heterostructures based on narrow-gap InAs-rich compounds

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Type II heterostructures in InAs-based solid solution systems have been intensively studied in recent years as promising candidates for the design of optoelectronic devices operating in the mid-infrared spectral range (3-5 μm). Asymmetric band-offsets at the type II heterointerface leads to formation of potential barriers for both electrons and holes simultaneously. Strong accumulation and effective confinement of the spatially separated electrons and holes in self-consistent quantum wells near the heteroboundary result in unusual optical and electrical properties of the heterostructures. Due to carriers' quantization interface (tunneling-assisted) radiative transitions exhibited high-temperature performance. However, there is a very important parameter, which must be taken into account in designing the laser structures based on narrow-gap compounds, is the spin-orbit splitting in the valence band. The resonance between the split-off valence bands and the energy of the emitted photons results in a significant increase of the Auger recombination rate and enhanced intervalence band absorption, which deteriorates the luminescent characteristics of the infrared emitters operating at the 3-5 μm.

We present temperature and compositional dependences of photoluminescence (PL) and photoreflectance (PR) spectra connected to the energy gap and the spin-orbit split off transition in $InGa_xAsSb_y/Ga_{0.84}In_{0.16}As_{0.22}Sb_{0.78}/InAs$ heterostructures [1]. The spin-orbit splitting compositional dependence for the GaInAsSb alloys system has been recognized as a nonlinear with the negative bowing parameter $C(\Delta_0)$=-0.25 eV. There are two points of the quaternary alloy compositions ($InGa_{0.03}AsSb_{0.06}$ and $InGa_{0.93}AsSb_{0.87}$) for which a resonance condition ($E_0 = \Delta_0$) can be realized at 77 K.

The quaternary solid solutions in the Ga-In-As-Sb and In-As-Sb-P systems can form type II heterojunctions with both staggered and broken-gap alignment. It was established that InAsSbP/InAs heterostructure is a type II staggered heterojunction in the whole composition range of the pseudomorphic InAsSbP epilayer. Intense interface electroluminescence in the type II staggered p-InAs/p-InAsSbP heterojunction was observed at T=300 K [2]. Transition from staggered to broken-gap alignment in type II heterostructures formed by the quaternary GaInAsSb alloys was demonstrated [3]. Suppression of the non-radiative recombination and enhancement of the interface luminescence was demonstrated in a type II broken-gap InAs/Ga(In)AsSb heterojunction [4].

This work was performed in framework of the programs of General Physics Division of RAS and was in part supported by Russian Basic Researches Foundation (grant #11-02-00234). In addition, M.M. would like to also acknowledge the Ministry of Science and Higher Education for financial support from the Iuventus Plus program.

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