Optical properties of quantum-dot-like InAs nanostructures grown by molecular beam epitaxy on InP substrate

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We present our recent work on the optical properties of InAs quantum-dot-like structures grown on InP substrate. In this material system and typically used growth conditions of molecular beam epitaxy (MBE) there are favorably formed strongly elongated structures called quantum dashes with lateral aspect ratio exceeding 5. They have widely been investigated and exploiting their intrinsic properties as e.g. high surface density or broad gain function there have been demonstrated improved performances in several laser device applications in telecommunication range especially [1]. However, there are application-relevant cases where a more symmetric and smaller quantum dot like objects could be indispensable, as they can offer higher gain due to increased ensemble homogeneity, lower threshold current, a possibility of unpolarized emission and higher characteristic temperature T_0 related to stronger confining potential in smaller nanostructures.

Within this communication we investigate almost symmetrical nanostructures of the abovementioned material system achieved by using As_2 instead of As_4 in the MBE growth process [2,3]. We used photoluminescence measurements combined with theoretical 8-band k·p modeling [4] to obtain the information on the electronic structure and the shape anisotropy of these dots. Polarization-resolved photoluminescence experiment was performed to measure the emission from an ensemble of QDs for two perpendicular linear polarization directions (according to the expected structure elongation axis), from both the surface and edge of the sample. This allowed us to obtain the respective degrees of polarization (DOP), which can directly be related to the structure geometry [4]. The obtained DOP from the surface is approx. 0.2, which is significantly less than for the strongly elongated dashes and gives the expected lateral aspect ratio of only about 2, in agreement with previous structural data [3]. This has further been confirmed by the DOP values for both the sample edges. Values of 0.8 and 0.38 were obtained for edges parallel and perpendicular to the object elongation axis. Also, the calculated separation of the energy levels is in the range of 10-50 meV, confirming the quasi-zero-dimensional character of these dots.

Additionally, we have studied the emission properties of these structures on the single dot level and detected several exciton and biexciton lines, identified based on rate equation modeling. The obtained exciton to biexciton lifetime ratio is of about 2, which is clear fingerprint of strong confinement regime.

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