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Doctoral dissertation abstract

„Carrier dynamics, photon emission statistics and phonon decoherence in single quantum dashes emitting in near infrared spectral region"

Semiconductor quantum dots are believed to be one of the key building blocks for a construction of a universal system for control of the charge carriers with light and for transfer of quantum information stored in carriers by radiative recombination of photons. By manipulation of shape, size and composition of a quantum dot it is possible to change its band structure, carriers' interactions and many other parameters which convert into optical properties. Actually, it is possible to manufacture strongly asymmetric nanostructures, such as quantum dashes in InAs on InP material system. Up to date such structures were studied mainly for applications as active areas in lasers and optical amplifiers.

This doctoral dissertation is focused on the optical properties of single quantum dashes emitting radiation in the near infrared. Its main goal is to study dynamics, decoherence mechanisms and photon emission statistics of exciton complexes confined in single InAs/InAlGaAs/InP quantum dashes emitting radiation in 1.3-1.6 μm spectral region. For this purpose a series of spectroscopic experiments, such as: microphotoluminescence, time-resolved microphotoluminescence and photon correlation measurements as well as theoretical simulations concerning coupling of acoustic phonons with excitons in quantum dashes have been performed. These studies allowed identifying exciton complexes originating from the same quantum dash and investigating dynamics of photon emission from particular complexes depending on excitation power and temperature. It enabled to analyze character of carriers' confinement potential in quantum dashes based on the excitons/carriers lifetimes. The photon auto-correlation studies of emission statistics from neutral and charged excitons was investigated, indicating sub-poissonian statistics which is characteristic for the single photon source. The obtained values of the second order correlation function at zero delays clearly indicated that InAs/InGaAlAs/InP quantum dashes can be characterized by single-photon emission and could be used in the future to construct single photon sources in telecommunication spectral range. In case of charged excitons it was possible to observe single-photon emission up to temperature of 80 K. Additionally, influence of temperature on exciton-phonon interaction was analyzed for different shapes of dashes and the main mechanism of the exciton states decoherence was identified, and recognized as exciton-phonon coupling via the deformation potential. Moreover, impact of quantum dash geometry on this effect was analyzed conforming the prediction that strongly elongated nanostructures should be less vulnerable to interaction with the acoustic-phonons than their symmetric counterparts.

The results presented in this dissertation are the first systematic set of data and information regarding the abovementioned aspects for semiconductor, epitaxial quantum dashes.