Two types of emitting states and energy relaxation in ZnCdSe/ZnSe quantum wells with planar CdSe nano-islands

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The dependence of the low temperature photoluminescence (PL) spectra of ZnCdSe/ZnSe QWs with CdSe planar nanoislands on the wave-length and polarization state of the exciting light has been studied in order to elucidate the nature of metastable and ground states responsible for the emission processes. The metastable and ground states contribute to the high-energy and low-energy part of the PL band, respectively [1].

It has been found that at the resonant excitation of the localized island states both by linear and circular polarized light the resulting emission of metastable states shows a considerable degree of polarization. This indicates that these emitting states have the exciton nature and are populated as a result of the energy relaxation of localized excitons originally excited within the islands.

At excitation of exciton states freely propagating along the QW plane, or the electronic states in the region of ZnSe barrier a red shift of the PL band maximum in comparison with that at resonant excitation conditions is observed. It can be concluded that such excitation populates preferably the ground states of the islands in the low-energy part of the PL band. The PL band maximum demonstrates a progressive red shift with the increase of the energy of excited photons, which indicates the gradual increase of the contribution of ground states of the islands.

We have concluded that the population of the ground states at excitation above the energy region of the island states represents a two-stage process corresponding to the successive trapping by the island of the two free carriers of the opposite sign. The independent relaxation of holes and electrons results in population of the deepest local potential minima of islands.

The different character of the island ground and metastable states is strongly confirmed by the polarization properties of emission at the selective excitation of the corresponding states by the polarized light. We have found that in distinction to the case of resonant excitation of metastable states, for ground states the linear polarization of emission at linearly polarized excitation (optical alignment) is not observed, whereas the circular polarization at circularly polarized excitation (optical orientation) is still detectable like in the former case.

We argue that polarization characteristics of the emission presented above can be explained if we assume that a considerable part of islands contains an extra electron and the deepest island states are formed by ground states of trions. Metastable states in charged island are the localized exciton states spatially separated from the excess localized electron.

[1] A.Klochikhin, A.Reznitsky, B.Dal Don, H.Priller, H.Kalt, C.Klingshirn, S.Permogorov, S.Ivanov, Phys.Rev. B 69 (2004).

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