Exciton-complex structure in electrically defined quantum dots of type II

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Even though the most popular quantum dots (QDs) are self-assembled dots (eg. GaAs/InAs), which trap simultaneously electrons and holes, the growing interest is now focusing on electrically defined dots being QDs of type II, which are dots for electrons and antidots for holes (or oppositely). These dots offer more flexible parameters in comparison to self-assembled dots and are promising due to continuous improvement of electrode preparation techniques. Though empty QD of type II attracts electron (e) and repulses hole (h) (or conversely), this dot can capture however e-h pair (X exciton) due to electric attraction of carriers. For weakly activated case, when not more than one exciton is localized in the dot, the double photoluminescence (PL) peak is observed at zeroth magnetic field, and the distance between peaks and their relative intensity are sensitive to variation of the dot diameter. For extremely small and large dots the main (left) peak is dominating while for medium dots both peaks are comparable. Simultaneously the blue-shift of all the PL spectrum is observed with decreasing dot diameter. For higher level of activation of QDs, with more than one exciton per dot, one can expect also complicated behaviour of PL features due to possible creation of exciton-like complexes, e.g. three-particle complexes of type e-e-h or h-h-e, called X^- and X^+, respectively. The analysis of the PL structure for higher excited QD type II is the topic of the present paper. We will show that taking into account three-particle complexes (e-e-h), three PL peaks can occur at zeroth magnetic field which split into four at magnetic field presence. The size dependence of localized X^- exciton-like complex is analysed within Hartree approach for Gaussian quantum dot of type II. For shallow and relatively large dots the Coulomb e-h interaction turns out to be sufficiently strong to significantly modify effective confinement potentials for electrons and a hole in e-e-h complex, resulting in multiple PL features in close analogy with experimental observations.

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