Excitons and Trions in modulation doped structures in high magnetic fields

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Modification of photoluminescence spectra taken from modulation doped CdTe/CdMgTe single QW structures have been studied in magnetic fields up to 45T as a function of 2D electron concentration in the QW.

We studied modulation-doped CdTe/($Cd_{0.7}Mg_{0.3}$)Te quantum well structures with a 2DEG of low, moderate and high density (n_e<10^{10} up to 10^{12} cm^{-2}).

In the PL spectra of lightly doped samples lines of the exciton and singlet trion state were observed. The exciton and trion radiation lines experienced a diamagnetic shift and Zeeman splitting nearly equal for all the lines. In the magnetic field higher than 25T a new line appeared in PL spectra. We identify this line as the triplet trion state. The binding energy of the triplet state in CdTe/CdMgTe QWs increased with magnetic fields from 0 to 3 meV in the field of 45T. This is in correlation with theoretical predictions, which show that in the absence of the magnetic field the triplet trion state is not bound and becomes bound only in high enough magnetic fields.

In low magnetic fields the intensity of the singlet trion line was much higher than that of the exciton, which is due to the high trion formation rate. With the growth of the magnetic fields the intensity of the singlet trion line decreased in both circular polarizations, meanwhile the intensity of the triplet trion line increases rapidly at magnetic fields close to 25T

A model calculation using the system of the kinetic equations describing the PL of the exciton-trion system was performed. The calculated dependences of the intensities of all the spectral lines on the magnetic field were close to the experimental.

The following peculiarities were found in relatively low magnetic fields for the samples with high electron concentrations when filling factors ν was higher than 2: (*i*) linear energy shift of the photoluminescence (PL) peak with increasing magnetic fields, (*ii*) periodic variation of PL intensities with maxima at even filling factors for σ^- and odd ones for σ^+ circular polarizations, (*iii*) smooth jumps of the PL peak at integer filing factors.

Such behavior is interpreted in a frame of combined exciton electron recombination processes. In such processes it is important that the initial and final states of the additional electron taking part in the process are not the same. In the initial state there is an exciton and a weakly bound with it additional electron in the states above the Fermi level. In the final state after the recombination of the exciton this electron should appear in the states above the Fermi level.

Although the residual electron after the exciton annihilation can have any energy from the Fermi energy to infinity, the probability of such processes decreases rapidly with increasing of the electron energy. Therefore, the maximum of the PL line in heavily doped samples at zero magnetic field is shifted to lower energies by the value of the order of the Fermi energy.

In the presence of magnetic fields the Fermi energy goes down and the PL peak shifts up in energy jumping from the higher Landau levels to the lower Landau levels as higher Landau levels become empty. It happens just when the filling-factor equals 2. At the lowest filling factors (ν<2) we observe a conventional excitonic/trionic behavior.