Magnetic field and temperature study of charge and degree of localization of excitonic complexes in GaAs/$Ga_{1-x}Al_xAs$ quantum wells

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We report on photoluminescence study of high-quality GaAs 15 nm quantum wells, asymmetrically carbon doped in barriers, in high magnetic fields up to 16 T and temperature from 2K to 30 K. We focus on low intensity recombination lines related to excitons localised by residual impurities positioned at different places: inside the quantum well and at the barrier. The different localization results in different total charge of the excitonic complexes. Excitons localised inside the quantum well are positively charged, whereas those localised at the barrier are neutral and negatively charged. In the first group, we detected radiative recombination of excitons bound on positively charged acceptors ($A_wX^+ = A^+ + X$) and their hole cyclotron replicas (SU-A_wX^+) whereas in second group excitons bound by negatively charged remote barrier acceptors (A_bX^-) and also their hole cyclotron replicas but with opposite transition of an additional hole (CR-A_bX^-). The temperature evolution of emission intensity of lines from both groups revels their different character (Fig.1a). The emission intensity of lines from the first group decrease with rising temperature. The detailed analysis of experimental data indicates that SU-A_wX^- complex has at least two dissociation channels with energies E_1=0.97meV and E_2=2meV (Fig.1b). The first channel occurs at low temperatures (T<8 K) and is related to dissociation of AX^+ into a spin-singlet A^+ and a free exciton ($AX^+ \rightarrow A^+ + X$), whereas the second one occurs at higher temperatures and is related to decay $AX^+ \rightarrow A + X^+$. The experimentally obtained ionization energies are in quite good agreement with results of our numerical calculation for the quantum well of the same width but different shape (symmetric [1]). In contrast, the intensity of CR-A_bX^- increase with temperature which is the clear proof of its substantially different nature.

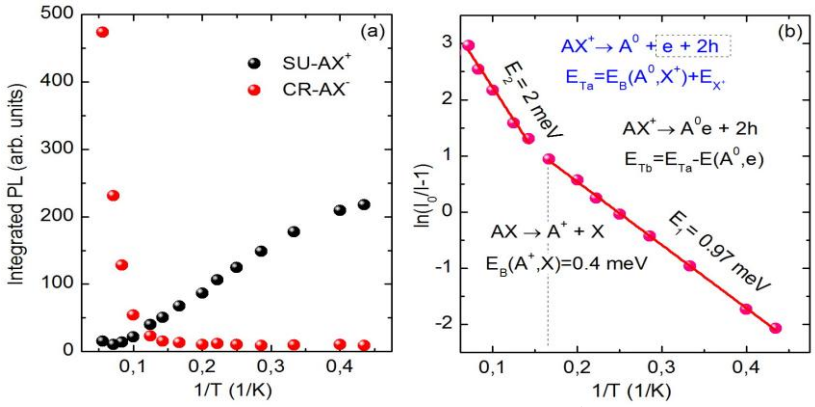

Fig.1 (a) Integrated intensity as u function of 1/T of SU-AX^+ and CR-AX^- lines, (b) Estimated activation energies associated with different dissociation processes of SU-AX^+.

1. L. Bryja, et al., Phys. Rev. B **75**, 035308 (2007).