Magnetic field induced excitons in photoluminescence from the heavily modulation doped p-type $Ga_{1-x}Al_xAs/GaAs$ single heterojunction

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We have studied polarisation resolved photoluminescence from p-type modulation doped $Ga_{1-x}Al_xAs/GaAs$ single junctions in temperature T=2K as a function of magnetic field up to 23T in Faraday configuration. We investigated the PL from five samples, two of Al mole content x=0.5 with two dimensional hole gas (2DHG) concentrations $p_1=7.6\cdot10^{11}cm^{-2}$ and $p_2=9.8\cdot10^{11}cm^{-2}$ and the hole mobility $\mu\sim10^4cm^2/Vs$. Three samples had Al content x=0.3, the 2DHG concentration $p_3=4.0\cdot10^{11}cm^{-2}$, $p_4=3.1\cdot10^{11}cm^{-2}$, $p_5=2.2\cdot10^{11}cm^{-2}$ and a very high hole mobility from $\mu=1.25\cdot`10^5cm^2/Vs$ to $\mu=7.99\cdot10^5cm^2/Vs$. In photoluminescence spectra from all samples we observed tree groups of interface related transitions. Two transitions we observed previously. The lowest energy one are the radiative recombination of photoexcited GaAs conduction band electrons trapped on donors with 2D holes confined at the interface. We named it D-line [1]. The second transition we attributed to the radiative recombination of photoexcited electrons with 2D holes. It is known in the literature as H-band. In this transitions the photoexcited electrons are not bound with 2D holes which manifests as its linear energy shift vs. magnetic field. Therefore we could determined experimentally 2D holes Landau levels energy dispersion [2]. The third group of lines exhibit a clear diamagnetic shift under the magnetic field and cannot be attributed, according to our theoretical calculations, to any recombination of unbound photoexcited electrons with 2D holes. In samples with very high 2DHG concentrations they appear in PL spectra in both, σ^+ and σ^- polarisations when appropriate H lines disappear from the spectra. This exchange take place at filling factors for which 2D holes Landau levels attributed to appropriate H transitions cross the Fermi level and start to fill with electrons. We accessed these lines to the radiative recombination of interface excitons. The nature of interface excitons is not quite clear. They can substitute free (X) or positively charged (X^+) excitons. In the first theoretical papers concerning charged excitons in 2D structures its observation in PL spectra from strongly anisotropy structures such as modulation doped single junctions were excluded. Nevertheless the observation of negatively charged excitons has been reported in n-type modulation doped $Ga_{1-x}Al_xAs/GaAs$ heterostructures. In the paper we analyse carefully all arguments concerning charged or neutral character of excitons in both heavily and modest doped p-type single junctions.

References

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