

Co-existence of excitonic and band-to-band transitions in the emission properties of a 2DEG in magnetic field

F. J. Teran¹, M. Potemski¹, G. Karczewski² and T. Wojtowicz²

¹ Grenoble High Magnetic Field laboratory, MPI/FKF - CNRS, Grenoble, France

² Institute of Physics, Polish Academy of Sciences, Warszawa, Poland

In spite of the large number of investigations, the optical properties of quantum wells are well understood only for two extreme cases: (i) when the concentration of the excess carriers (for instance, electrons) is negligible (exciton binding energy, E_b much bigger than Fermi energy E_F). The emission and absorption spectra are then dominated by excitonic effects (ii) when the excitons are completely screened at high carrier densities ($E_b \ll E_F$). In this case, the optical spectra can be understood within the framework of single particle transitions whereas the effects of electron-electron interaction are included by simply considering the renormalization of the fundamental bandgap. Investigations in the intermediate regime ($E_b \sim E_F$) are more complicated since they underline the possibility of the formation of bound states involving more than two-particles.

Here we report on optical studies of modulation doped CdMnTe quantum well nanostructures, with electron concentration ranging from $\sim 1 \times 10^{10}$ – 6×10^{11} cm⁻². The experiments consist of polarization resolved luminescence and luminescence excitation measurements at low temperatures and magnetic fields up to ~ 28 T.

At low electron densities the optical response is observed to be determined by excitonic resonances (neutral and negatively charged excitons). With increasing electron concentration, broadening of the emission peaks on the low energy side and broadening of the absorption peaks on the high energy side is observed. These, low and high energy spectral tails evolve correspondingly into cyclotron-resonance shake-up and exciton-cyclotron combined resonances when magnetic fields are applied. Further increase of electron concentration leads to appearance of the renormalized interband transitions (inter Landau level transitions in magnetic fields) by electron-electron interactions.

Our investigation reveals a persistence of excitonic transitions at high electron densities for which the Fermi energy is comparable to the exciton binding energy. We observe a coexistence, tuned by magnetic field, of band to band and excitonic-like transitions in samples with electron concentration as high as 6.3×10^{11} cm⁻². This raises the question whether such observations are characteristics for systems with homogenous carrier density or they imply an effect of phase separation, i.e., a formation of "insulating islands" and "lakes of electrons" with well-defined electron concentration. Indeed, spatially resolved micro-photoluminescence experiments corroborate this idea. Our data shows that the carrier concentration changes up to 30 % at different places on the sample.

Phone: +33 (0) 4 76 88 78 56

fax: +33 (0) 4 76 85 56 14

email: fjteran@grenoble.cnrs.fr