High mobility two-dimensional electron gas in CdTe quantum wells: High magnetic field studies

Experimental studies of two-dimensional electron gases confined in CdTe and CdMnTe quantum wells are presented. The data analysis is supported by numerical calculations of the band structure of confined states, using the local density and envelope function approximations. Four by four, k.p calculations have been performed to justify the parabolic approximation of valence bands. Samples were characterized by Raman scattering spectroscopy and far infrared cyclotron resonance absorption measurements. Low-field magneto-transport shows the dominant contribution of the semi-classical Drude conductivity and three orders of magnitude weaker contributions of weak localization, electron-electron interaction and Shubnikov-de Haas oscillations. The contribution of electron-electron interactions is explained within a semi-classical model of circling electrons. The shape of Landau levels, broadening, transport and quantum lifetimes and dominant long-range scattering mechanism have been determined. High-field magneto-transport displays fractional quantum Hall states at Landau levels $N = 0$ and $N = 1$. The ground states $5/3$ and $4/3$ have been determined to be fully spin polarized, in agreement with the approach of composite fermions for the fractional quantum Hall effect. The form of the photoluminescence at zero magnetic field and its evolution with temperature have been described by simple analytical model. Magnetic field and temperature dependence of the photoluminescence has been found to display the enhanced spin splitting of fully occupied Landau levels. This many body enhanced spin gap has been successfully described by a numerical model. The intensity of the photoluminescence demonstrated the importance of the non-radiative recombination channel, degeneracy of Landau levels, their occupation, selection rules and screening. The mechanism of the simultaneous electron and hole spin-flip was recognized and attributed to the longitudinal acoustical phonon assisted Bir-Aharonov-Pikus spin relaxation mechanism. Photoluminescence excitation spectra embody the characteristic density of states of two-dimensional systems. The excitonic resonances, which are observed at the edges of unoccupied electric subbands, illustrate the importance of screening and internal electric fields in asymmetrically doped quantum wells.

Keywords: Two-dimensional electron gas, integer and fractional quantum Hall effect, electron-electron interaction, optical spectroscopy and electronic transport at high magnetic fields and low temperatures.