EFFECTS OF PARALLEL MAGNETIC FIELD ON FERMI ENERGY IN A 2-DIMENSIONAL ELECTRON GAS

Y. D. Jho (NHMFL and UF), J. Kono (Rice, ECE), D.H. Reitze (UF, Physics), C. J. Stanton (UF, Physics), A.C. Gossard (UCSB, Materials)

Introduction

The multiple electron-hole (e-h) scattering rate for electrons close to Fermi energy E_F changes the bound state at E_F into a power-law singularity in an electron plasma of density $n^e \sim 10^{12}$ cm^{-2} [1]. The strength of the singularity can be modified by applying magnetic field, through magnetic confinement and spin-coupled (and orbital-coupled with perpendicular field) motion with parallel field in 2-dimensional electron gas (2DEG). Here we study the photoluminescence (PL) spectra of a 2DEG using in-plane and perpendicular magnetic fields (up to 33 T) and their correlations with resistivity.

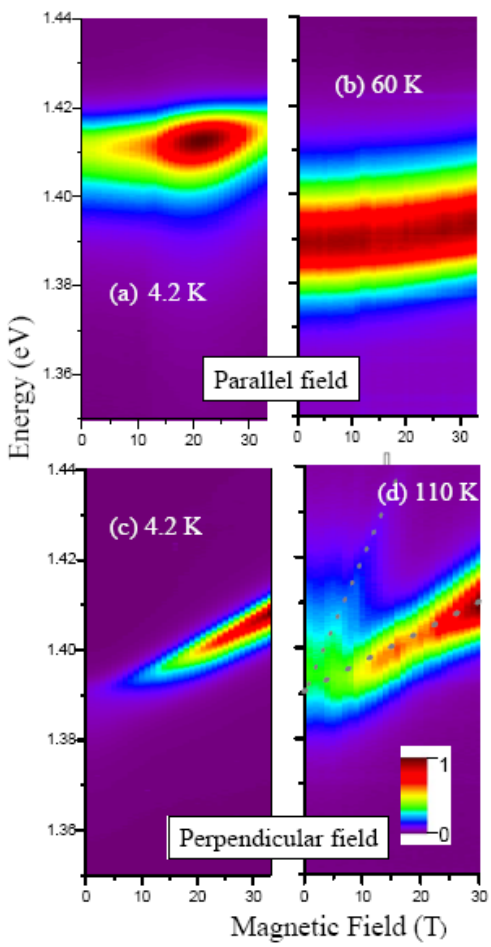

Fig. 1 Contour plot of the PL intensity versus (a,b) parallel field or (c,d) perpendicular field at various temperatures.[2]

Experimental

Experiments were performed on *n*-type modulation-doped $In_{0.2}Ga_{0.8}As/Al_{0.41}Ga_{0.59}As$ quantum wells ($n^e \sim 1.4\text{x}10^{12}$ cm^{-2}) at various temperatures. Fig. 1 shows contour maps of PL spectra (normalized with maximum intensity shown in deep red) around the Fermi edge singularity (FES) with increasing magnetic field up to 33 T with (a,b) parallel or (c,d) perpendicular field.

Results and Discussion

The PL intensity as a function of field at the Fermi edge E_F (main peak) in Fig. 1 shows a quenching behavior around 20 T at (a) low temperature with parallel field in clear contrast to the case of (c) perpendicular field. Thus, the PL spectra imply that only the parallel field can suppress the multiple electron scattering in this high doping density regime. On the other hand, by comparing Fig. 1(c) with Fig. 1(d), we find Landau levels (indicated by gray dotted lines in (d)) are formed only at high temperature where the electrons can be unbound to their parent impurity ions. The optical quenching behavior in Fig. 1(a) has been correlated with the observation of increased resistivity enhanced at low temperature (not shown), suggesting that optical signatures may be a precursor of a metal-insulator transition.

Conclusions

We have performed PL spectroscopy and transport measurements on a 2DEG system. Correlations between PL quenching and resistivity increase are seen with parallel field,

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References

[1] M.S. Skolnick *et al.*, Phys. Rev. Lett. **58**, 2130 (1987).