MAGNETOLUMINESCENCE OF ASYMMETRIC GaAs/AlGaAs COUPLED DOUBLE WELL STRUCTURES

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Introduction

Coupled double quantum well (CDQW) structures, where the two wells are separated by a thin barrier, are of interest due to an enhanced quantum Stark effect and provide an ideal system for studying tunneling dynamics. Modulation-doping of a CDQW creates two parallel two-dimensional electron gas (2DEG) layers. This additional electronic degree of freedom in the growth (**z**) direction can be controlled by varying the barrier thickness, external gate voltages, and magnetic fields. For a strong tunneling structure, wherein two quantum wells are separated by a very thin barrier (typically < 40 Å), a tunnel split bandgap is formed such that the symmetric and antisymmetric states are nearly degenerate in energy.

Experimental Results and Discussion

We report highly non-linear photoluminescence emission spectra in pulsed magnetic fields of three MBE grown modulation-doped asymmetric GaAs/$Al_{0.3}Ga_{0.7}As$ coupled double quantum wells (ACDQW). Figure 1 depicts the potential profile of the sample used for this study. The width of the square quantum well and the thin barrier are 70 (80, 100) and 25 Å, respectively. In such structure, the conduction band has tunnel split energy levels (E_1 and E_2) whereas the valence band has no such levels because left side of the valence band is unbound. In Fig. 2, with low laser power (0.10 mW), new optical transitions emerge around 28 T (ν=1). We also observed non-linear transition behavior at around 14 T (ν =2) as seen in Fig. 2 inset. These new transitions are due mainly to the tunneling dynamics of the valence holes. At zero field, photogenerated holes in the quantum well leaked and tend to move to the GaAs flat band, such that optical transition occurs between the conduction band electrons (E_1 and E_2) to unbound holes located near the GaAs flat band. External magnetic fields reduce screening within two-dimensional electron gas. Enhanced Coulomb attraction between holes and electrons due to the reduction of the screening prevents holes from leaking from the quantum well. As a result, well to well transition (from E_1 and E_2 to HH_1) emerges in strong magnetic fields.

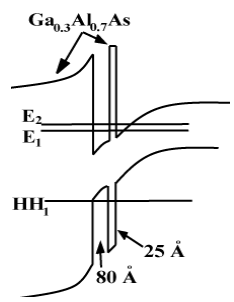

Figure 1. GaAs/AlGaAs ACDQW structure used for this study.

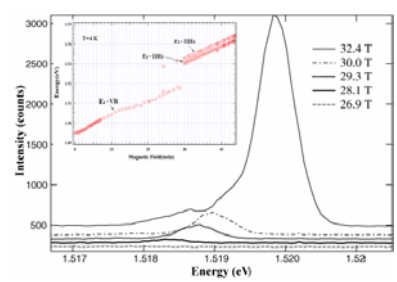

Figure 2. Magnetic-field-induced PL spectra of ACDQW

With increasing laser power, these new peaks appear lower magnetic fields. Fig. 3 shows external laser power versus magnetic fields that new peaks emerging. This behavior is not unusual. As seen in Fig. 2, the non-linear effects occur near the integer quantum Hall region. Increasing laser power increases electron density in the well and as a result, the quantum limit (ν=1) becomes higher magnetic field. We speculate that as hole density increases with increasing laser power, significant number of holes tend to stay in the quantum well and recombine with the conduction electrons at low magnetic fields.

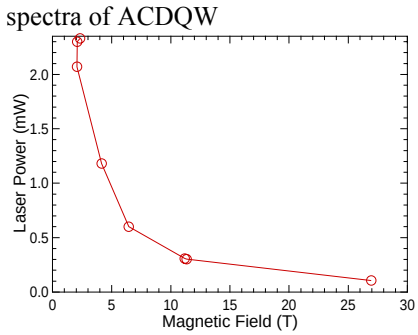

Figure 3. Magnetic field where discontinuous transition appears decreases with increasing laser power.

We conclude that strong magnetic fields are able to alter tunneling dynamics of charged carriers in asymmetric coupled double wells. Time-decay measurements of the transitions are needed for further investigations of such tunneling dynamics.

Acknowledgements

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