Interlayer Tunneling in Mixed-Type GaAs Quantum Wells at High Magnetic Field

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Introduction

We report an experimental study on the tunneling of holes in an electron-hole bilayer system formed in a GaAs mixed-type quantum well (MTQW). In these bilayer systems, an interlayer correlation between holes and excitons can strongly enhance the hole tunneling rate [1]. This opens a new avenue for optical control of a transport process in semiconductors.

As part of a larger study on MTQW hole tunneling [2], we investigated how the interlayer hole tunneling process changes in high magnetic fields.

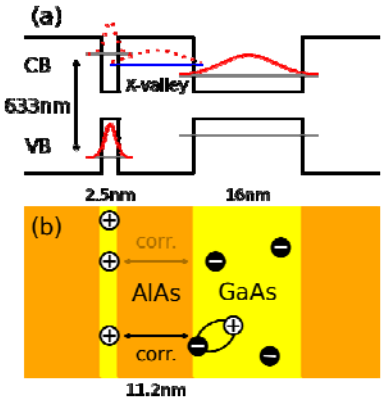

Figure 1: a) Band-edge profile of MTQW. b) Interlayer correlations involving excitons influence the hole tunneling time.

Experimental

In a MTQW, a narrow GaAs well (NW) is separated by a thin AlAs barrier from a wide GaAs well (WW) (Fig. 1). The NW is type-II with respect to the barrier, leading to spatial separation of photoexcited electrons and holes into the WW and NW, respectively [3]. The result is an electron-hole bilayer with a lifetime limited by the rate at which holes tunnel through the AlAs barrier (order ms). Tunneling rates are measured by monitoring the strength of exciton absorption in the WW.

Electron-hole pairs were excited using a HeNe laser pulsed by an acousto-optic modulator. A weak diode laser tuned to the WW exciton line was used to probe time-dependent absorption of the sample, from which tunneling times were extracted.

Magnetic fields were applied using the 25T split-bore magnet. The sample was oriented in the Faraday geometry by a custom sample holder and held at 10K by a helium cryostat.

Results and Discussion

Fig. 2a shows the dependence of the tunneling rates as a function of the applied field, in which no qualitative change is observed. In contrast, Fig. 2b demonstrates that, at field, tunneling rates are not affected by the exciton density, contrary to what is observed at 0T.

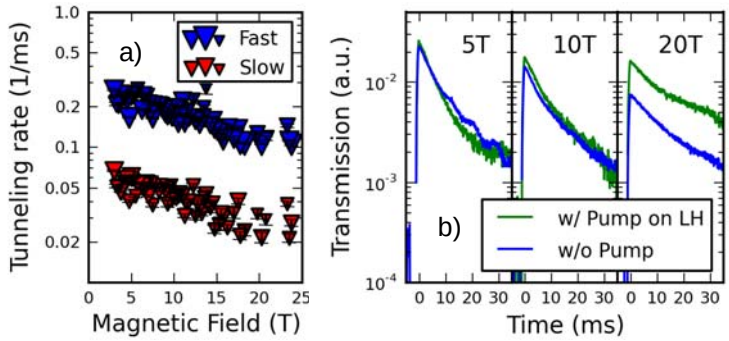

Figure 2: a) Dependence of tunneling rate on magnetic field. b) Tunneling curves with and without exciton injection.

This can be understood in the context of reduced mobility of excitons in a magnetic field [4]. At 0T, NW holes are localized by well width fluctuations, but WW excitons are relatively mobile. By arranging themselves opposite the holes, they form local correlations which accelerate tunneling. If exciton diffusion is frozen out by the magnetic field, this arrangement could not occur, quenching the exciton-correlated tunneling.

Conclusions

We find that the magnetic field quenches the ability of WW excitons to accelerate the rate of hole tunneling. We interpret this as further evidence that exciton-correlated tunneling results from a local cross-barrier correlation between excitons and holes, based on the diffusive properties of excitons in high magnetic fields.

Acknowledgements

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References

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