Isotropic vs. Anisotropic Transport in the Field Induced Wigner-Crystal State in 2D Holes

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Introduction

Strong Coulomb interactions are expected to drive two-dimensional (2D) carriers in semiconductor hetero-interface into a crystal ground state in the ultra-low density regime. A perpendicular magnetic field can stabilize this Wigner crystal (WC) state at higher carrier densities such that the disorder effect is weak. Besides 2D Wigner crystal and metallic liquid, a number of isotropic or anisotropic states were predicted in theories: stripe, WC bubble in liquid etc. [1] We studied transport of strongly interacting 2D holes in high mobility GaAs quantum wells (QWs) to investigate the effects of current transport direction on the magnetic field induced WC state in low fields which is shown a reentrant insulating phase (RIP) in the magneto-transport data [2].

Experimental

Low frequency magneto-transport measurements using lock-in technique were primarily performed on high mobility GaAs QW samples from wafers grown on (311)A GaAs. $Al_{0.1}Ga_{0.9}As$ barriers and Si delta doping layers were placed symmetrically at a distance of 195 nm away from the 10 nm thick GaAs QW. All the samples have density $p \sim 1.3 \times 10^{10}/cm^2$ and mobility $\mu=5\times10^5$ cm^2/Vs without gating. A back gate was placed approximately 0.3mm underneath the sample and used to tune the hole density. Current was applied along two perpendicular directions: [$\underline{2}$33] and [01$\underline{1}$] to compare if the insulating behavior in the RIP (or WC) state is isotropic or not.

Results and Discussion

The RIP due to WC formation at low *B* has been observed [2] as related to the strongly interacting character of the dilute 2D hole system and high sample quality. This RIP was found to exist in both current directions. Due to the corrugation of GaAs's (311)A surface, the mobility along [$\underline{2}$33] is a few times higher than the [01$\underline{1}$] direction, causing the resistance values to be different for these two current flow configurations. However, a clear insulating peak is found around ~0.3Tesla for both directions, indicating that the RIP is isotropic, not due to orientation order like one expects in stripe phases.

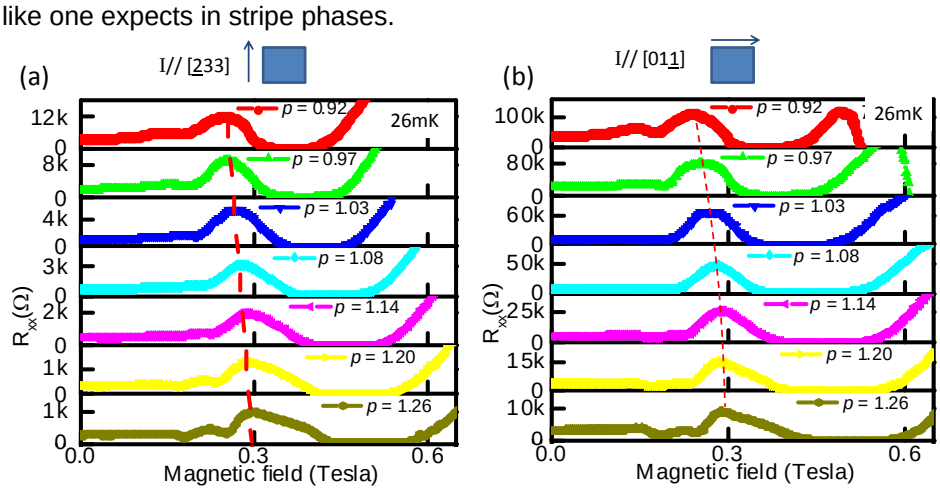

Fig.1 Magneto-resistance of a square shaped 2D hole GaAs QW sample measured with current along two perpendicular directions. The density *p* is in units of $10^{10}/cm^2$. Experimental temperature was 26mK. The red dashed line in both (a) and (b) indicate the location of reentrant insulating phase due to WC.

Conclusions

By measuring the magneto-transport along two different current flow directions, we found that the RIP phase in dilute 2D holes in GaAs QWs is not related to anisotropic stripe phase, confirming its relation to the WC with quasi-long range position order.

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References

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