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Electronic Transport Studies in a Lateral Quantum Dot Array Sample

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Introduction

It is of great recent interest to study transport properties in two-dimensional electron systems (2DES) subjected to both a lateral periodic modulation and a quantizing magnetic field. These large-area nanostructures are expected to give rise to many interesting phenomena through the interplay of different length and energy scales [1].

Experimental

Experiments were carried out in a high quality quantum well with the two-dimensional electron gas buried 200 nm below the surface. The quantum dot array is defined by a Ti/Au metal grid, which was fabricated using the interferometric lithograph and lift-off techniques. Conventional low frequency (~ 13 Hz) lock-in technique was used to measure the magnetoresistance R_{xx} and Hall resistance R_{xy}.

Results and Discussion

Around zero magnetic field, a pronounced positive magnetoresistance is observed, which can be explained by the semi-classical model of magnetic breakdown. The so-called commensurability oscillations together with the usual Shubnikov-de Hass oscillations are also observed. This demonstrates that indeed the 2D potential can be modulated by the interferometric lithograph defined metal grid. By measuring R_{xx} and R_{xy}, we show that in the presence of modulation the usual integer quantum Hall states remains well developed at low temperatures. Temperature dependence was also carried out for R_{xx}, from which we have determined the activation energy gap for the integer quantum Hall states at $\nu=1$ and $\nu=2$. Interestingly, in a pure DC measurement of R_{xx}, an anomalous resistance spike is clearly seen. The magnetic field position of this resistance spike depends on the amplitude of the applied DC bias (V_{ds}) between the source and drain, and shows roughly $1/V_{ds}$ dependence. No such anomaly is observed in the samples without metal grid.

Conclusions

We have measured the magnetoresistance and Hall resistance in a two-dimensional quantum dot array sample. The observed electron transport anomaly is probably due to the potential modulation.

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References

[1] See, for example, Beenakker, C.W.J. and van Houten, H., in *Solid State Physics*, edited by H. Ehrenreich and D. Turnbull (Academic Press, San Diego, 1991), Vol 44, P.1.