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Determination of Electron Effective Mass and g-Factor in InAsSb Quantum Wells

Pendharkar, M. (UCSB, ECE); Lee, J.S. (UCSB, CNSI); McFadden, A.P. (UCSB, ECE); Seas, M. (UCSB, Materials); Palmstrøm, C.J. (UCSB, ECE, CNSI, Materials)

Introduction

Quantum wells and quantum wires of highly spin orbit coupled materials of InAs and InSb are of special interest to the field of topological quantum computation due to their high spin-orbit coupling (high g-factor) and low electron effective mass. Near surface quantum wells allow for realization of etch-defined nanowires, paving the way for realization of scalable superconductor-semiconductor hybrid networks. An increase in spin-orbit coupling, and mobility is expected to lead to an improvement in the induced topological gap, increasing topological protection. Certain compositions of $InAs_xSb_{1-x}$ are expected to have a lower effective mass and higher g-factor than both InAs and InSb, due to band gap bowing. This work explores low temperature high field magneto-transport of $InAs_{0.2}Sb_{0.8}$ quantum wells.

Experimental

Temperature dependence measurements of Shubnikov-de Haas oscillations observed under a perpendicular magnetic field were used for determination of electron effective mass, while angle dependence of magneto-transport measurements at high fields was use for determination of electron g-factor, in near surface InAsSb/InAlSb quantum wells on GaSb substrates, 15nm and 25nm deep from surface. Experiments were performed on SCM-1 in the milli-Kelvin facility in 2018.

Results and Discussion

On adding in-plane magnetic field, along with out-of-plane magnetic field, the maxima in resistance, between integer states shift according to the g-factor of the channel. The NHMFL's SCM-1 is uniquely positioned to perform such an experiment at 20mK and 18 Tesla, due to its integrated sample rotation stage, allowing for out-of-plane to in-plane rotation of the sample. Fig.1(a) shows the maxima in resistance, with increasing sample tilt angles from 90 degrees (perpendicular magnetic field) to ~10 degrees (major part of the applied field in-plane). The g-factor measured from these experiments was estimated to be ~38.

It was observed that the lowest temperatures, achievable in SCM-1, of ~20mK were necessary for observation of Integer Quantum Hall states in InAsSb, touching zero-resistance. Elevated temperatures lead to an immediate lifting of the observed states from the expected minima or zero-resistance and a temperature variation of 20-400mK was used to measure the temperature dependence of Shubnikov-de Haas oscillations, as shown in Fig. 1(b).

Conclusions

Integer Quantum Hall Effect in near surface InAsSb quantum wells was measured at low temperatures, under high magnetic fields, to determine the electron effective mass and g-factor.

Acknowledgements

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References

[1] Pendharkar, M., *et al.*, *in preparation*

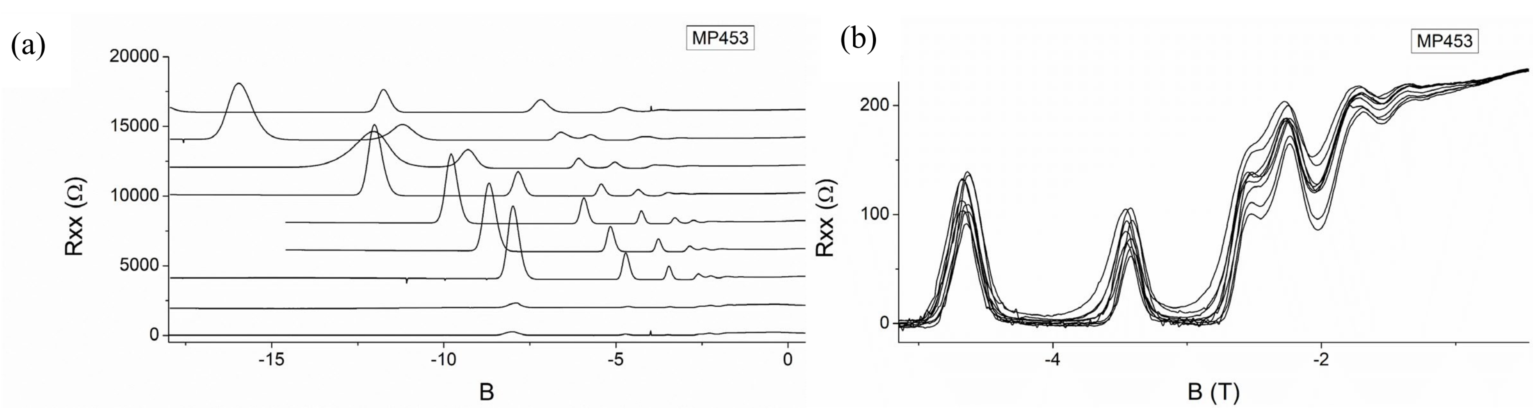

Fig.1 (a) Longitudinal resistance (Rxx) vs magnetic field at 20mK, with changing sample tilt angle from 90 degrees (perpendicular field, lowest trace) to 10 degrees (highest trace). (b) Rxx vs magnetic field with varying temperatures from 20mK to ~400mK.