# Charge Neutral Regime of Nanoscale InAs/GaSb Coupled Quantum Well

A. Saminathan[1,2*], M. E. Kelly[1,2], M. C. Rosamond[2], L. H. Li[2], S. Sasaki[1], E. H. Linfield[2], C. H. Marrows[1]

[1]*School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, United Kingdom*

[2]*School of Electronic and Electrical Engineering, University of Leeds, Leeds, LS2 9JT, United Kingdom*

[*]*A.Saminathan@leeds.ac.uk*

The discovery of quantum spin Hall systems [1-3] represents a leap in novel semiconductor research due to their potential application in spin-based communication devices. The quantum spin Hall state or the two-dimensional topological insulator state has been proposed to be supported by the coupled InAs/GaSb quantum well system where the band inversion is found to open a hybridization gap [4]. Electrostatic gating is required to tune into the hybridization gap to explore the spin-polarized edge states. In the present work, an AlSb (50 nm)-sandwiched InAs/GaSb (15 nm/8 nm) quantum well wafer has been patterned into gated nano-scale Hall bar devices. The magnetotransport behaviour at 1.5 K has been studied in the presence of a top gate (TG) voltage. Fig. 1 shows the effect of increasing negative top gate voltage on the longitudinal sheet resistance ($R_s$) and the Hall resistance ($R_{xy}$). $R_s$ rapidly increases with increasing magnitude of top gate voltage and saturates at -6 V. The magnitude of $R_{xy}$ exhibits a peak at -4.2 V, indicating a depletion of the net carrier density at the Fermi level. The linearity of the Hall resistance as a function of magnetic field is lost with increasing magnitude of negative top gate voltage indicating a crossover from a single-carrier transport regime into a two-carrier regime, with a net sheet carrier minimum at -4 V (inset a). This indicates that the $R_s$ saturation region hosts both *n*-type and *p*-type carriers due to tuning the Fermi level away from the conduction band of the InAs well and into the charge-neutral regime. Further studies will probe the signatures of spin-polarized current in this regime.

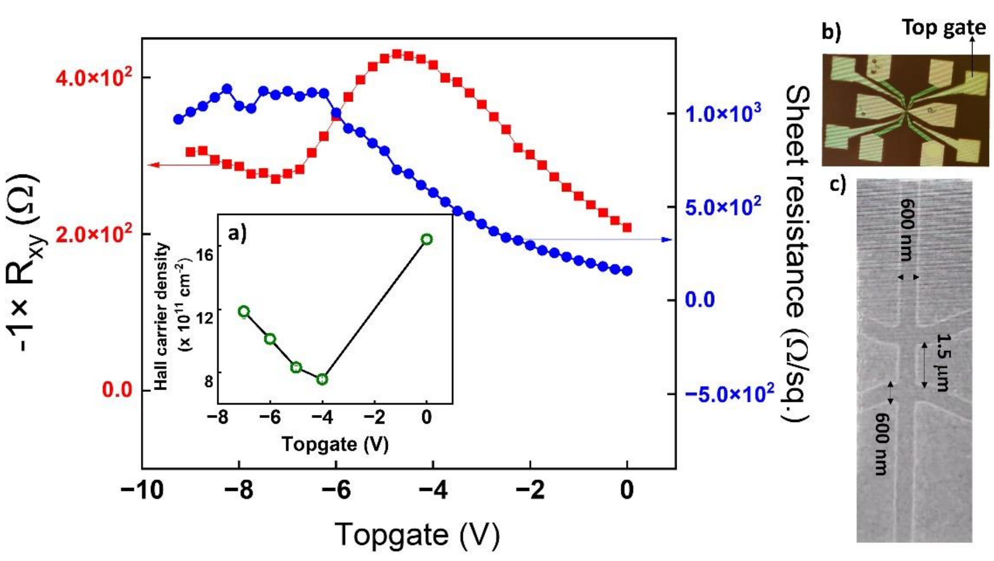


Figure 1. Variation of Hall resistance and longitudinal sheet resistance with the top gate voltage at 1.5 K. Inset a) Variation of net sheet carrier density with top gate voltage, b) Optical micrograph of the gated six-probe Hall bar device, c) Scanning electron microscopy image of the six probe Hall bar.

References

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