Advances in electron transport in InSb/$Al_xIn_{1-x}Sb$ quantum wells

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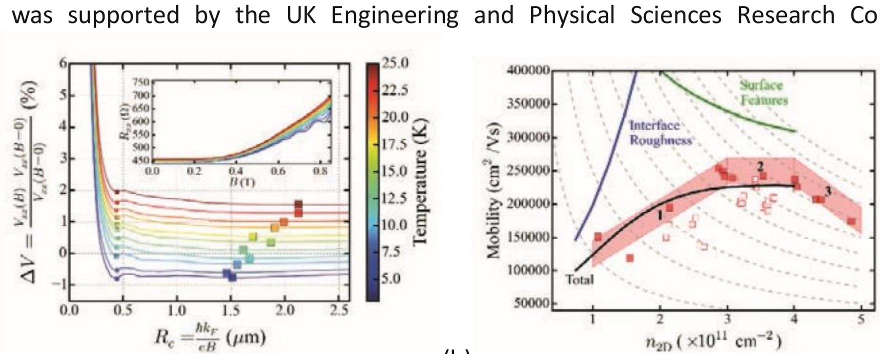
Narrow-gap indium antimonide (InSb) based heterostructures are of increasing interest for use in quantum transport devices. InSb exhibits the lowest electron effective mass (m^* = 0.014 m_e) and highest reported room-temperature electron mobility ;l = 78,000 cm^2/Vs) of any compound semiconductor, as well as a strong spin-orbit interaction and large Landé *g*-factor (*g* y 50). These properties have gained attention for use in spintronics and quantum information control, as well as the possibility of the realisation of Majorana Fermions in a system where potentially advanced planar fabrication can be exploited.

We report on advances in electronic transport measurement and corresponding modelling of high mobility InSb/$Al_xIn_{1-x}Sb$ quantum well heterostructures, demonstrating the critical scattering mechanisms across a range of samples [1]. Through the use of Differential Interference Contrast DIC (Nomarski) optical imaging we have observed characteristic surface roughness [2], and we present evidence for the effects of these on magnetoresistance measurements. Using a Monte Carlo model combined with Drude transport modelling, and modified 2D Landauer-Büttiker tunnelling calculations [3], we show that transport in these structures can be successfully described using a potential barrier model for grain boundaries, where these effective Schottky like barriers are inferred to pin at y 78% of the mid gap value. We further expand on this model using an analytic approximation to accurately predict the low temperature mobility behaviour. Using a modified transport model combined with this potential barrier scheme we can successfully describe measured mobilities across a wide range of samples and demonstrate that there is the potential for vast improvements in this material system given correct buffer redesign and significant defect reduction.

This work was supported by the UK Engineering and Physical Sciences Research Council. a)



(b)

Fig. 1: a) Magnetoresistance measurements as a function of temperature showing local minima associated with proposed scattering mechanisms (surface feature related scattering and background impurity scattering). Inset) Corresponding longitudinal R_{xx} resistance against *B*-field. b) Carrier density (n_{2D}) vs mobility for a series of samples with increased doping (filled squares), with 3 regions shown. Lines show transport model fit with limiting contributions labelled [2].