Edge Transport in InAs/GaSb Topological Insulating Phase

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We have investigated transport properties of InAs/GaSb heterostructure system [1,2], for which a topological insulating phase and thus quantum spin Hall effect (QSHE) are predicted. Although complete quantization has not been achieved, non-local resistance measurements provide compelling evidence that, for a sample with appropriate layer thicknesses, the current flow is governed by edge transport.

The samples studied are InAs (top)/GaSb (bottom) heterostructures sandwiched between $Al_{0.7}Ga_{0.3}Sb$ barriers with varying InAs layer thickness (w = 10, 12, and 14 nm). The Hall bars have six Ohmic contacts with a distance of 2 μm and a top gate. When the Fermi level is tuned in the band gap, a resistance maximum is observed for all the samples, with markedly different resistance values [Fig. (a)]. For the w = 10 nm sample, the peak resistance increases with decreasing temperature (T) and reaches several MΩ at 0.25 K, indicating that the system is a fully gapped normal insulator. In the w = 14 nm sample, the low peak resistance of only 2 kΩ and the absence of T dependence indicate a semimetallic band structure. In contrast, in the w = 12 nm sample, the peak resistance saturates at low T at a value quite close to $h/2e^2$, i.e., the quantized value expected for QSHE in the six-terminal geometry used.

Non-local resistance measured for the w = 12 nm sample showed resistance values comparable to $h/6e^2$ for all configurations, as expected for helical edge transport in a six-terminal device [Fig. (b), (c)]. Interestingly, despite the resistance fluctuations and deviations from $h/6e^2$ indicative of inelastic scattering processes, when we focus on the resistance ratio for adjacent contact pairs, in the gap region, the ratio is found to be identical for different current injection/ejection paths [boxed region in Fig. (d)], including the details of the fluctuations (inset). Similar results were confirmed for all combinations of adjacent contact pairs. As is seen in the p- and n-type regions (V_{FG} < 1.27 V and V_{FG} > 1.42 V), when bulk transport is dominant, the resistance ratio reflects the current distribution in the bulk and thus takes different values for different current paths. The observed perfect agreement in the gap region, in turn, clearly demonstrates that the current flows only between adjacent contacts along the sample edge. It is shown that, with our six-terminal non-local measurements, the resistances of all the individual edge channels can be deduced.

[1] Liu *et. al.*, Phys. Rev. Lett. **100**, 236601 (2008).
[2] Knez *et. al.*, Phys. Rev. Lett. **107**, 136603 (2011).

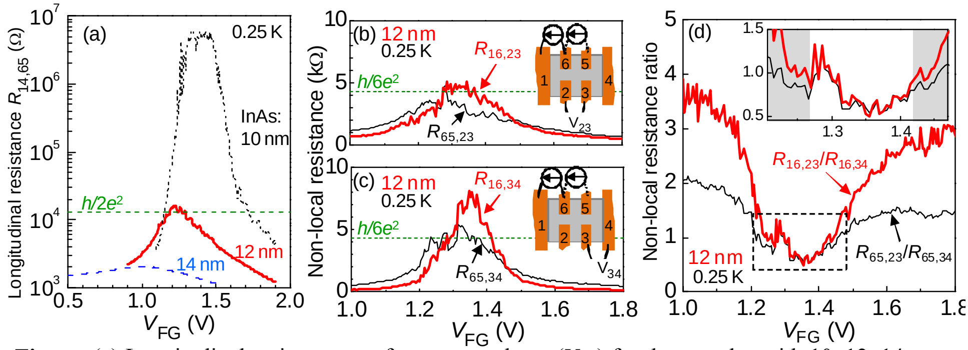

Figure. (a) Longitudinal resistance vs front gate voltage (V_{FG}) for the samples with 10, 12, 14 nm InAs. (b) and (c) Non-local resistances for the sample with 12 nm InAs. (d) Non-local resistance ratios between adjacent contact pairs, measured for different current injection/ejection paths.