Bilayer-induced asymmetric quantum Hall effect in epitaxial graphene

A. Iagallo,[1] S. Tanabe,[2,a] S. Roddaro,[1] M. Takamura,[2] Y. Sekine,[2] H. Hibino,[2] V. Miseikis,[3] C. Coletti,[3] V. Piazza,[3] F. Beltram,[1,3] and S. Heun[1]

[1] *NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, 56127 Pisa, Italy*

[2] *NTT Basic Research Laboratories, 3-1 Morinosato Wakamiya, Atsugi, Kanagawa, 243-0198, Japan*

[3] *Center for Nanotechnology Innovation @ NEST, Istituto Italiano di Tecnologia, 56127 Pisa, Italy*

[a] *Present address: NTT Device Technology Laboratories, Atsugi, Kanagawa, 243-0198, Japan*

stefan.heun@nano.cnr.it

In the quantum Hall (QH) regime, the Hall resistance is quantized at rational fractions of the universal quantum h/e^2, and since 1990 the QH effect is used as the primary resistance standard [1]. Graphene is recently emerging as a new ideal material for QH metrology [2] and has the potential to outperform existing material alternatives. Indeed, thanks to its particular linear dispersion relation, at a given magnetic field intensity graphene offers a much larger energy spacing between the first Landau levels compared to GaAs-based systems. As a consequence, magnetic field and temperature requirements for the observation of the QH effect are less demanding for graphene and already allowed the observation of resistance quantization at room temperature [3].

Devices based on epitaxial graphene on SiC(0001) could offer a route for scalable applications [2]. Epitaxial graphene on SiC is obtained by annealing SiC wafers at high temperature. The unavoidable presence of a slight wafer miss-cut causes a number of atomically-sharp step edges separated by flat terraces across the crystal surface where nucleation of multilayer graphene domains is favored. This results in the formation of narrow multilayer inclusions - typically bilayers – that run along the SiC step edges and can have a detrimental impact on the transport properties.

Here we investigate electron transport in epitaxial graphene on SiC(0001) at quantizing magnetic fields. Devices patterned perpendicularly to SiC terraces clearly exhibit bilayer inclusions distributed along the substrate step edges (Fig. 1c). We show that transport properties in the QH regime are heavily affected by the presence of bilayer inclusions, and observe a significant departure from the conventional QH characteristics. In particular, we observe anomalous values of the quantized resistance and a peculiar asymmetry with magnetic field (Fig. 1ab) that was never reported for graphene on SiC. A quantitative model based on the Landauer-Büttiker picture and involving enhanced inter-channel scattering mediated by the presence of bilayer inclusions is presented (Fig. 1d) that successfully explains the observed symmetry properties.

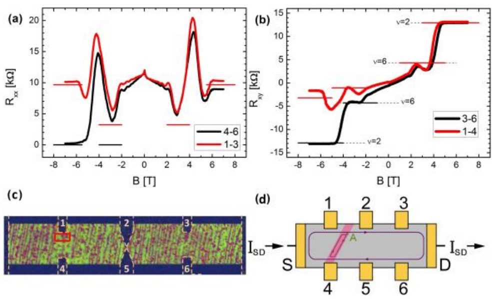

Fig.1: Quantum Hall traces in a device containing graphene bilayer shunts: a) longitudinal and b) transversal resistance. c) Raman map of the device showing monolayer (light green) and bilayer (dark) graphene regions. The outline of the contacts is superimposed. d) Schematics of edge-state arrangement for a bilayer inclusion.

References

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