Condensed Matter Theory Center

center for nanophysics and advanced materials

Condensed Matter Colloquium

Thursday, November 1, 2012
2 pm, Room 1201

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Surface conduction of topological Dirac electrons in bulk insulating Bi_2Se_3

The three dimensional strong topological insulator (STI) is a new phase of electronic matter which is distinct from ordinary insulators in that it supports on its surface a conducting two-dimensional surface state whose existence is guaranteed by the topology of the band structure of the insulator. Like graphene, the STI surface state generically has a Dirac electronic spectrum with massless electrons and a vanishing bandgap at a Dirac point. I will discuss experiments on the STI material Bi_2Se_3, which has a bulk bandgap of 300 meV, much greater than room temperature, and a single topological Dirac surface state. Field effect transistors consisting of thin (3-20 nm) Bi_2Se_3 are fabricated from mechanically exfoliated from single crystals, and electrochemical and/or chemical gating methods are used to move the Fermi energy into the bulk bandgap, revealing the ambipolar gapless nature of transport in the Bi_2Se_3 surface states. The minimum conductivity of the topological surface state is understood within the self-consistent theory of Dirac electrons in the presence of charged impurities. The intrinsic finite-temperature resistivity of the topological surface state due to electron-acoustic phonon scattering is measured to be 60 times larger than that of graphene largely due to the smaller Fermi and sound velocities in Bi_2Se_3 [2], which will have implications for topological electronic devices operating at room temperature. In the thinnest Bi_2Se_3 samples (~3 nm) we observe the opening of a bandgap due to coupling of the top and bottom surfaces which hybridize to form a conventional two-dimensional insulator[3], and by controllably thinning regions of Bi_2Se_3 samples we achieve quantum dots with gate-tunable insulating barriers[4].

[1] D. Kim et al., Nature Physics 8, 460 (2012).
[2] D. Kim et al., Phys. Rev. Lett. 109, 166801 (2012).
[3] S. Cho et al., Nano Letters 11, 1925 (2011).
[4] S. Cho et al., Nano Letters 12, 469 (2012).

Refreshments at 1:30 pm in Room 1305F

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