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Surface conduction of topological Dirac electrons in bulk insulating Bi_2Se_3

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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 topology. 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 surface state with a massless Dirac dispersion. 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 $\sim$60 times larger than that of graphene largely due to the smaller Fermi and sound velocities in Bi_2Se_3, which will have implications for topological electronic devices operating at room temperature. As samples are made thinner, coherent coupling of the top and bottom topological surfaces is observed through the magnitude of the weak anti-localization correction to the conductivity, and, in the thinnest Bi_2Se_3 samples ($\sim$ 3 nm), in thermally-activated conductivity reflecting the opening of a bandgap.