Gate tunable normal and superconducting transport through a 3D topological insulator

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We report on transport experiments though very thin Bi_2Se_3 layers, exfoliated from high quality single crystals and transferred onto a Si/SiO_2 substrate acting as a gate. Low-temperature magneto-resistance measurements exhibit clear Shubnikov de Haas oscillations, which can be tuned by applying a gate voltage. The plot of the resistance as a function of magnetic field and gate voltage exhibit a fan diagram of Landau levels originating from both electrons and holes at the surface closer to the gate electrode, whose quantitative analysis allows us to determine the Dirac character of the charge carriers. Shubnikov de Haas oscillation due to carriers on the surface far away from the gate are also observed as features in the fan diagram that do not depend on the gate voltage (which is screened by the first and by carriers in the bulk). Our analysis also shows that an impurity band is present inside the gap of the bulk bands of Bi_2Se_3, with a large density of states that coexist with the surface states. Finally, as the devices are fabricated with superconducting contacts, we succeeded in observing Andreev reflection and proximity induced supercurrent. The critical current is gate tunable and exhibits a bipolar behavior, with a minimum at the same gate voltage observe from extrapolating the fan diagram of Landau levels. This observation indicates that at least part of the supercurrent is carried by Dirac electrons and holes at the surface.

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