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Characterization of surface conducting states in $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ topological insulator single crystals JANGHEE LEE, JOONBUM PARK, JAE-HYEONG LEE, JUN SUNG KIM, HU-JONG LEE, Department of Physics, Pohang University of Science and Technology, Pohang 790-784, Republic of Korea — Topologically protected surface state (TSS) of a topological insulator (TI) can be described in terms of a spin-resolved Dirac band with helical-spin texture. In general, however, as-grown TIs are doped so that the surface conduction can be dominated by the bulk conduction. In this study, we minimized the bulk conduction using high-quality $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ TI thin single crystals, with the Fermi level lying in the bulk gap without gating. We confirmed that the weak anti-localization (WAL) effect and universal conductance fluctuations in our samples arose from the top and bottom surfaces. By back-gate tuning the WAL characteristics, we identified the TSS conducting characteristics and the coupling between the TSS and the topologically trivial two-dimensional electron gas (2DEG) states that emerged due to the band bending near the surface. The ambipolar Hall resistivity of the bottom surface was consistent with the back-gate-voltage dependence of the longitudinal resistance of the TSS. This study provides a highly coherent picture of the surface transport properties of TIs by successfully differentiating the transport of the TSS from those of the bulk conducting state and the topologically trivial 2DEG states.

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