Emergent surface superconductivity in a 3D topological insulator.¹

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Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Surfaces of three-dimensional topological insulators have emerged as one of the most remarkable states of condensed quantum matter where exotic charge and spin phases of Dirac particles could form. This work reports on novel mesoscopic superconductivity in the topological insulator Sb₂Te₃ with transition to zero resistance induced through a minor tuning of growth chemistry that depletes bulk conduction channels [1]. The depletion shifts Fermi energy towards the Dirac point as witnessed by a factor of 300 reduction of bulk carrier density and by the largest carrier mobility (>25,000 cm²V⁻¹s⁻¹) found in any topological material of this class. Direct evidence from transport, the unprecedentedly large diamagnetic screening, and the presence of ~ 25 meV gaps detected by scanning tunneling spectroscopy reveal the superconducting condensate to emerge first in surface puddles at unexpectedly high temperature of ~ 50 K, with the onset of global phase coherence at ~ 9 K. The unconventional spin response of Sb₂Te₃ [2] and the presence of subsurface 2DEG quantum well states arising from charge transfer to the surface [3] are likely to play a role in the emergent superconducting state. The rich structure of this state lends itself to manipulation via growth conditions and the material parameters such as Fermi velocity and mean free path.


¹This work was supported by NSF DMR-1122594, DMR-1420634, DMR-1322483, and DOD-W911NF-13-1-0159.