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Emergent surface superconductivity in a 3D topological insulator.[1]

LIA KRUSIN-ELBAUM, Department of Physics, The City College of New York CUNY

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 Sb_2Te_3 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 $cm^2V^{-1}s^{-1}$) found in any topological material of this class. Direct evidence from transport, the unprecedentedly large diamagnetic screening, and the presence of $\sim$ 25 meV gaps detected by scanning tunneling spectroscopy reveal the superconducting condensate to emerge first in surface puddles at unexpectedly high temperature of $\sim$ 50 K, with the onset of global phase coherence at $\sim$ 9 K. The unconventional spin response of Sb_2Te_3 [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.

[1] Emergent surface superconductivity in the topological insulator Sb_2Te_3, L. Zhao, H. Deng, I. Korzhovska, J. Secor, M. Begliarbekov, Z. Chen, E. Andrade, E. Rosenthal, A. Pasupathy, V. Oganesyan, and Lia Krusin-Elbaum, *Nature Comm.* **6**, 8279 (2015); DOI:10.1038/ncomms9279. [2] Singular robust room-temperature spin response from topological Dirac fermions, L. Zhao, H. Deng, I. Korzhovska, Z. Chen, M. Konczykowski, A. Hruban, V. Oganesyan and Lia Krusin-Elbaum, *Nature Mat.* **13**, 580 (2014); DOI: 10.1038/nmat3962. [3] Robust topological interfaces and charge transfer in epitaxial Bi_2Se_3/II-VI semiconductor superlattices, Z. Chen, L. Zhao, K. Park, T. A. Garcia, M. C. Tamargo, and Lia Krusin-Elbaum, *Nano Lett.* **15** (10), 6289 (2015); DOI:10.1021/acs.nanolett.5b01358.

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