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Magnetism in Magnetically Doped Topological Insulators[1]

KE HE, Department of Physics, Tsinghua University

A topological insulator (TI) has topologically non-trivial electronic property induced by spin-orbit coupling (SOC) and protected by time reversal symmetry (TRS). Breaking the TRS of a three-dimensional (3D) TI with ferromagnetism can gap the Dirac surface states and induce novel quantum phenomena. Magnetic doping is a convenient approach to introduce magnetism into a TI. A crucial issue is if long-range ferromagnetic order could be built in magnetically doped TIs in the insulating regime. Combining angle-resolved photoemission spectroscopy, scanning tunneling microscopy, transport measurement, and first principles calculation, we have systematically studied the surface band structure, magnetism and transport properties of molecular beam epitaxy-grown Cr-doped 3D TIs: Bi_2Se_3, Bi_2Te_3, and Sb_2Te_3. We have found that Cr-doped Bi_2Te_3, Sb_2Te_3 and their alloys show long-range ferromagnetic order robust against variation in charge carriers. The ferromagnetism is likely mediated by the strong van Vleck susceptibility of the host materials due to the SOC-induced inverted band structure. Cr-doped Bi_2Se_3, on the other hand, could not show long-range ferromagnetic order, but exhibit gap-opening at the Dirac surface states. The absence of long-range ferromagnetic order and the observed gapped surface states are partly due to the superparamagnetic multimers formed by Cr dopants, and partly due to significant reduction of the SOC of Bi_2Se_3 by Cr substitution for Bi, which turns off the van Vleck mechanism.

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