Emergent interfacial superconductivity at the interface of topology and magnetism

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Project Summary: Heterogeneous interfaces that juxtapose different materials have been known to create emergent quantum phenomena. We used molecular beam epitaxy to synthesize heterostructures formed by stacking together two magnetic materials, a ferromagnetic topological insulator $(Cr,Bi,Sb)_2Te_3$) and an antiferromagnetic metal, iron chalcogenide (FeTe). High-resolution transmission electron microscopy (HRTEM) and x-ray diffraction show the formation of heterostructures with sharp interfaces and good crystallinity. Neither of these materials is a superconductor in the native crystalline form. Yet, we observed emergent interface-induced superconductivity in these heterostructures, Using a combination of angle resolved photoemission spectroscopy (ARPES), electrical transport, reflection magnetic circular dichroism (RMCD), magnetic force microscopy, scanning tunneling microscopy, and muon spin relaxation, we demonstrated the coexistence of topological band structure, superconductivity, and ferromagnetism in the magnetic topological insulator layer. Thus, these new hybrid magnetic/topological/superconducting heterostructures provide the three essential ingredients needed for 'chiral topological superconductivity' and are an attractive wafer-scale platform for the exploration of a viable route toward Majorana physics.

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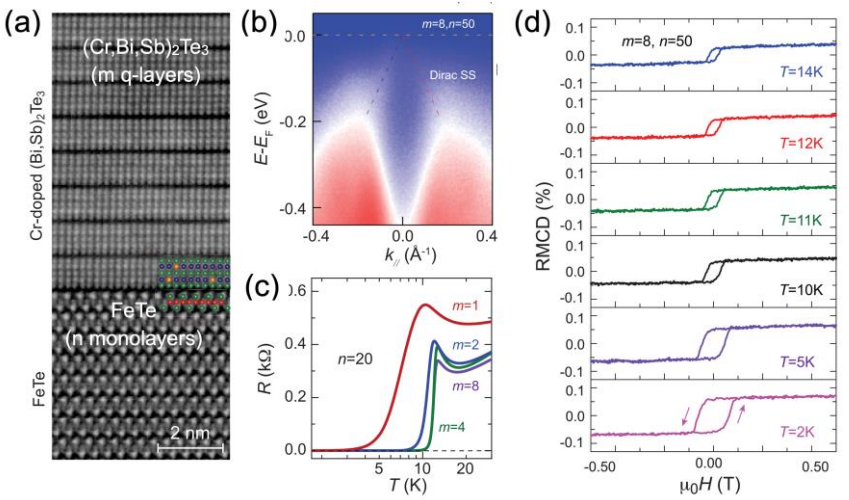
2DCC Role: 2DCC facility was partially used for epitaxial growth of high-quality FeTe/$(Bi,Sb,Cr)_2Te_3$ heterostructures and their characterization using *in vacuo* ARPES. This project primarily involved personnel from the Penn State MRSEC and collaborators at Rutgers, Univ. Washington, and NIST.



Above (a): HRTEM image of a FeTe/$(Cr.Bi.Sb)_2Te_3$ heterostructure. (b) ARPES spectrum of the sample shown in (a). (c) Resistance versus temperature in 3 samples, showing a superconducting transition. (d) RMCD measurements showing the presence of ferromagnetism in a heterostructure even in the superconducting phase.