Discovery of a 3D topological insulator: samarium hexaboride

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One of the longest-studied mixed valent insulators, Samarium Hexaboride (SmB_6), exhibits a mysterious residual resistivity at low temperatures ($T < 4$ K), but at a value too high to explain within the framework of bulk conduction [1]. All efforts over the years to eliminate this resistivity have failed. The recently conjectured existence of a topologically protected surface state in SmB_6 [2] could resolve the long-standing mystery surrounding its low-temperature transport properties.

We developed a novel configuration (Fig. 1) designed to distinguish bulk-dominated conduction from surface-dominated conduction by exaggerating the geometric differences between the two conduction paths through contacts placed on both sides of a thin sample. The results of this experiment (Fig. 2) show that below 3 K, SmB_6 has a fully-insulating bulk and an intrinsic metallic surface with a remarkably high conductivity [3]. We argue that the robustness of the surface conductivity is a signature of the topological protection of the surface states. This discovery resolves the old mystery about the strange transport behavior of this material, and it provides a material in which 2D transport properties of a true topological state can be studied. We will also present some of our results from transport experiments using a Corbino geometry.

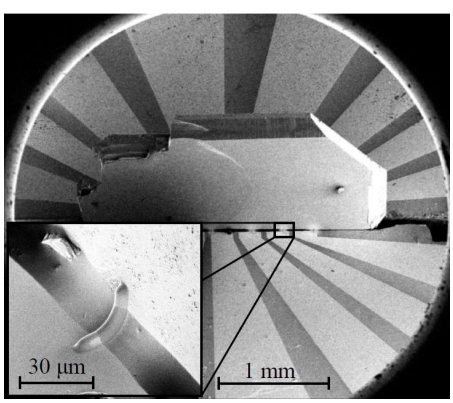

Figure 1 Picture of sample. A thin crystal of SmB_6 is sandwiched between two Si wafer pieces. Several Pt contacts connect both the front and back sides of the sample to Au contact pads on the Si pieces. **Inset** Close-up of a Pt contact.

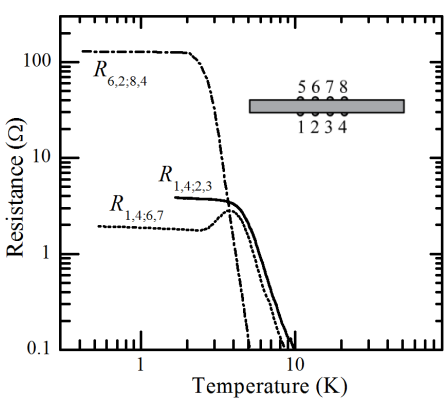

Figure 2 Various 4-terminal resistances plotted against temperature. The data shows a crossover from bulk conduction to surface conduction between 3 – 5 K. In the absence of a crossover, the resistances would differ only by constant scaling factors.

[1] J. W. Allen, B. Batlogg and P. Wachter, Phys. Rev. B **20**, 4807 (1979).
[2] M. Dzero, K. Sun, V. Galitski and P. Coleman, Phys. Rev. Lett. **104**, 106408 (2010).
[3] S. Wolgast, Ç. Kurdak, K. Sun, J. W. Allen, D. J. Kim and Z. Fisk, arXiv:1211.5104v2.