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Electric Field Tuned Quantum Phase Transition from Topological to Conventional Insulator in Few-Layer Na3Bi

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Na3Bi in bulk form represents a zero-bandgap topological Dirac semimetal (TDS), but when confined to monolayer it is predicted Na3Bi is a 2D topological insulator with a bandgap of ~300 meV.1 Application of an electric field to few-layer Na3Bi has been predicted to induce a topological phase transition, opening up the possibility of creating new types of electronic switches known as 'topological transistors'.2 However, opening a bandgap in TDS has proven elusive, as efforts to grow thin films have only succeeded in growing 15-20 nm films that remain zero-bandgap semimetals.

In this talk I will discuss our efforts in growing epitaxial few-layer Na3Bi via MBE, and then subsequent measurements of the electronic structure and response to an electric field using scanning probe microscopy/spectroscopy and angle-resolved photoelectron spectroscopy. We demonstrate that few-layer Na3Bi is a 2D topological insulator with a bandgap >400 meV. Furthermore, via application of an electric field the bandgap can be tuned to semi-metallic and then re-opened as a trivial insulator with bandgap greater than 100 meV. The electric fields required to induce this transition are below the breakdown field of many conventional dielectrics, making the creation of a topological transistor based on a few-layer TDS within reach.

1 C. Niu, et al., Phys. Rev. B 95, 075404 (2017)
2 H. Pan, et al., Scientific Reports 5, 14639 (2015)

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