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Demonstrating an electric field-tuned Topological Phase Transition in ultra-thin film Na3Bi using ARPES and STM

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The electric field induced quantum phase transition from topological to conventional insulator has been proposed as the basis of a topological field effect transistor. In such a device an electric field can switch 'on' the ballistic flow of charge and spin along dissipationless edges of the two-dimensional (2D) quantum spin Hall insulator [1], and when 'off' is a conventional insulator with no conductive channels. Here we demonstrate that few-layer Na3Bi, normally a 3D Topological Dirac semimetal in its bulk[2][3], is a viable platform for realising such a topological transistor at room temperature.

Using scanning tunnelling microscopy (STM)/spectroscopy (STS), supported by complementary angle-resolved photoelectron spectroscopy (ARPES), we observe that mono- and bilayer Na3Bi behave as effectively 2D topological insulators with bulk bandgaps >400meV.

Further, we demonstrate that upon the application of an external electric field [4] with an STM tip, a topological phase transition to trivial insulator with conventional gap greater than 100meV can be reversibly induced. The large bandgaps in both the conventional and quantum spin Hall phases suggest that Na3Bi is suitable for room temperature topological transistor operation.

References:

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Primary author(s) : Mr COLLINS, James (Monash University)

Co-author(s) : Dr TADICH, Anton (Australian Synchrotron); Dr GOMES, Lidia (Department of Physics and Centre for Advanced 2D Materials, National University of Singapore, 117551, Singapore); Mr WU, Weikang (Research Laboratory for Quantum Materials & EPD Pillar, Singapore University of Technology and Design, Singapore 487372, Singapore); Dr RODRIGUES, Joao (Department of Physics and Centre for Advanced 2D Materials, National University of Singapore, 117551, Singapore); Mr LIU, Chang (School of Physics and Astronomy, Monash University, Clayton VIC 3800, Australia); Dr HELLERSTEDT, Jack (School of Physics and Astronomy, Monash University, Clayton VIC 3800, Australia); Dr RYU, Hyejin (Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA); Dr TANG, Shujie (Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA); Dr MO, Sung-Kwan (Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA); Prof. FUHRER, Michael (School of Physics and Astronomy, Monash University, Clayton VIC 3800, Australia); Dr EDMONDS, Mark (School of Physics and Astronomy, Monash University, Clayton VIC 3800, Australia)

Presenter(s) : Mr COLLINS, James (Monash University)

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