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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 >400 meV.

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 100 meV 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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