Michael S. Fuhrer[a,b,c]

[a]ARC Centre of Excellence in Future Low-Energy Electronics Technologies, Monash University, Victoria 3800, Australia
[b]Monash Centre for Atomically Thin Materials, Monash University, Victoria 3800, Australia
[c]School of Physics & Astronomy, Monash University, Victoria 3800, Australia

michael.fuhrer@monash.edu

High-Quality Epitaxial Thin Films of Topological Dirac Semimetal Na_3Bi

Topological Dirac semimetals (TDS) are three-dimensional analogues of graphene, with linear electronic dispersions in three dimensions. Here we demonstrate TDS thin films, with electronic transport and scanning tunnelling microscopy (STM) performed in ultra-high vacuum (UHV). Such films open numerous new possibilities, including studying the conventional-to-topological quantum phase transition (QPT) as a function of layer thickness or incorporating gate electrodes to enable an electric field-tuned QPT, realizing a topological transistor. Na_3Bi thin films are grown by molecular beam epitaxial and transferred in UHV a low-temperature STM capable of magnetotransport at 5 K. Thin films (20 nm) of Na_3Bi on α-Al_2O_3(0001) substrates are found to possess low temperature charge carrier mobilities exceeding 6000 $cm^2V^{-1}s^{-1}$ with n-type carrier densities below 1 x 1018 cm^{-3}[1], comparable to the best single crystal values. Mapping the local Dirac point via scanning tunneling spectroscopy reveals a high degree of spatial uniformity, with rms variations in Dirac point energy less than 5 meV[2], comparable to the best graphene samples on hexagonal boron nitride. Chemical doping[3] and electrostatic gating[4] (using SiO_2/Si substrates) can be used to tune the carrier density and allow a closer approach to the Dirac point.

References

[1] J. Hellerstedt, M. T. Edmonds, N. Ramakrishnan, C. Liu, B. Weber, A. Tadich, K. M. O'Donnell, S. Adam, M. S. Fuhrer Nano Letters 16, 3210 (2016).
[2] M.T. Edmonds, J.L. Collins, J. Hellerstedt, I. Yudhistira, S. Adam, M.S. Fuhrer, ArXiv:1612.03385.
[3] M.T. Edmonds, J. Hellerstedt, K.M. O'Donnell, A. Tadich, and M.S. Fuhrer, ACS Appl. Mater. Interfaces 8, 16412 (2016).
[4] J. Hellerstedt, I. Yudhistira, M.T. Edmonds, C. Liu, J. Collins, S. Adam, and M.S. Fuhrer, in preparation.