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Air-Stable Electron Depletion of Bi2Se3 Using Molybdenum Trioxide into the Topological Regime

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Topological insulators, such as Bi2Se3, are a new class of material that possess topologically protected Dirac surface states that hold great promise for next generation nano-electronic devices [1]. However, major challenges exist in realizing Bi2Se3 devices that operate in the topological regime in air. The first is that as-prepared Bi2Se3 is invariably n-type doped due to selenium vacancies [1], where the Fermi level resides in the bulk conduction band, not within the Dirac surface states necessary to realize these electronic devices. The second is that Bi2Se3 when exposed to atmosphere becomes further n-type doped and degrades over time [2].

Utilizing high-resolution photoelectron spectroscopy on in-situ cleaved Bi2Se3 single crystals we demonstrate that the strong electron acceptor molybdenum trioxide (MoO3) is capable of depleting ~1013 cm-2 electrons from Bi2Se3 to place the Fermi level well within the topological regime. We implement a doping model based on Fermi-Dirac statistics to accurately describe the doping behaviour as a function of MoO3 coverage. Furthermore, in-situ transport measurements on MBE grown Bi2Se3 films are used to demonstrate that a 100 nm film of MoO3 is also capable of protecting Bi2Se3 from degradation upon exposure to atmosphere and further n-type doping [3].

References:

[1] Y. Xia, et al., Nature Physics 5, 398 (2009)
[2] D. Kong, et al., ACS Nano 5, 4698 (2011).
[3] M. T. Edmonds, et al., ACS Nano 8, 6400 (2014).

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Summary

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