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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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