MAR14-2013-020347

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Direct electrical detection of spin-momentum locking in the topological insulator $\mathbf{Bi_2Se_3}$

CONNIE H. LI, Naval Research Lab

Topological insulators (TIs) are a new quantum state of matter [1] characterized by metallic surface states populated by massless Dirac fermions. TIs are expected to exhibit new behaviors and open horizons for science previously inaccessible with "conventional" materials. One of the most striking properties is that *of spin-momentum locking* – the spin of the TI surface state lies in-plane, and is locked at right angle to the carrier momentum. An unpolarized charge current should thus create a net spin polarization whose amplitude and orientation are controlled by the charge current. This remarkable property has been anticipated by theory [2], but never accessed in a simple transport structure. Here we show that a bias current indeed produces a net surface state spin polarization *via* spin-momentum locking in molecular beam epitaxially grown Bi_2Se_3 films, and this polarization is directly manifested as a voltage on a ferromagnetic metal contact. This voltage is proportional to the projection of the TI spin polarization onto the contact magnetization, is determined by the direction and magnitude of the bias current, scales inversely with Bi_2Se_3 film thickness, and its sign is that expected from spin-momentum locking rather than a Rashba effect [3]. Similar data are obtained for structures with two different ferromagnet/tunnel barrier contacts, demonstrating that these behaviors are independent of the details of the detector contact. These results demonstrate direct electrical access to the TI surface state spin system and enable utilization of its remarkable properties for future technological applications.

[1] J. E. Moore, Nature **464**, 194 (2010); M. Z. Hasan et. al., Rev. Mod. Phys. **82,** 3045 (2010); L. Fu et. al., PRL **98**, 106803 (2007); D. Hsieh et. al., Nature **452**, 970 (2008).
[2] A. A. Burkov et. al. PRL **105**, 066802 (2010); D. Culcer et. al., PRB **82**, 155457 (2010); V. Yazyev et. al., PRL **105**, 266806 (2010).
[3] S. Hong et. al., PRB **86**, 085131 (2012).