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Optimizing Spin Generation in 2D Materials: Topological Insulators and Graphene

CHING-TZU CHEN, IBM Thomas J Watson Research Center

Novel two-dimensional electronic systems with Dirac-like dispersion present unique opportunities for spintronic applications. In this seminar I will discuss two specific examples. First we examine the potential of topological insulators as spin-source materials. Using a new spin-polarized tunneling method [1], giant charge-spin conversion efficiency in topological insulators is revealed, well exceeding that in conventional magnetic tunnel junctions.[2] Through a comparative study between Bi2Se3 and (Bi,Sb)2Te3, we verify the topological-surface-state origin of the observed giant spin signals and further extract the energy dependence of the effective spin polarization in Bi2Se3.[2] Next we explore the potential of interfacial exchange interaction in 2D materials for spin control and spin generation. Using graphene as a prototype, we demonstrate that its coupling to a model magnetic insulator (EuS) produces a substantial magnetic exchange field (>14 T), which yields orders-of-magnitude enhancement in the spin signal originated from the Zeeman spin-Hall effect.[3] Furthermore, the strong exchange field lifts the spin degeneracy of graphene in the quantum Hall regime, which may lead to interesting spin-polarized edge transport and thus open up new application space for classical and quantum information processing. [1] Luqiao Liu, Ching-Tzu Chen, J. Z. Sun, Nature Physics 10, 561–566 (2014). [2] Luqiao Liu, A. Richardella, Ion Garate, Yu Zhu, N. Samarth, and Ching-Tzu Chen, Physical Review B 91, 235437 (2015). [3] Peng Wei, Sunwoo Lee, Florian Lemaitre, Lucas Pinel, Davide Cutaia , Wujoon Cha , Donald Heiman, James Hone, Jagadeesh S. Moodera, Ching-Tzu Chen, Giant Interfacial Exchange Field in a 2D Material/Magnetic-Insulator Heterostructure: Graphene/EuS, arXiv:1510.05920.