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Surfaces, interfaces, and ultrathin films of topological insulators

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Three-dimensional topological insulators are characterized by an inverted bulk band gap caused by a strong spin-orbit coupling. This gap must close at the surface and reopen outside in vacuum where the gap is noninverted (and infinite). The resulting metallic surface states, or topological states, are spin-polarized and span the bulk gap. They carry a spin current, independent of the details of the surface, which is a feature of strong interest for spintronic applications. This talk will focus on thin films of topological materials (Sb, Bi_2Se_3, and Bi_2Te_3). Thin films are basic building blocks of devices, which typically involve multilayers of various materials. As the thickness of a topological insulator film is reduced to the nanoscale, the bulk bands are reduced to discrete quantum well states, and the surface/interface states associated with the two faces of the film can interact, resulting in spin mixture and formation of a tunneling gap. The detailed atomic bonding at each face of the film can also affect the overall electronic structure of the system. The interplay of quantum confinement, topological order, spin polarization, and surface/interface bonding and chemistry will be discussed. This work was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Grant No. DE-FG02-07ER46383.