Photocurrent in topological materials

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Materials with strong spin-orbit interaction show intriguing opto-electronic functionalities, including optical excitation of spin subsystem and generation of spin-current/spin-polarized charge-current. Dirac and Weyl materials are of recent interest, due to the possible wide-band operation coming from their zero-gap nature and the Berry phase contributions to excite large zero-bias photocurrents[1,2)].

Doping topological materials with magnetic elements brings about essential modifications in their originally mass-less Dirac dispersion, providing an additional path towards exotic physics and future dissipation-less electronics.[3,4)] With the progress in film fabrication techniques including modulation doping,[5)] we will be able to explore a variety of electron/spin dynamics at the modified Dirac states and cooperative phenomena between two surfaces (top/bottom of a film) in topological insulators.

Here we discuss several optical responses observed in (magnetic) topological insulators (TIs); (i) enhancement of photogalvanic current by chemically tuning the Fermi energy,[6)] and (ii) generation of large zero-bias photocurrent resulting from magnetic interactions.[7)] When a TI thin film is doped with magnetic elements, such as Cr, its easy-axis anisotropy induces an energy gap at the Dirac point. The surface-state dispersion recovers its mass-less state by the application of an in-plane magnetic field, due to the helical nature of the spin in the k-space, and further shifts/deforms through the Zeeman effect. In this situation, the photoexcitation at $+k_x$ and $-k_x$ becomes non-equivalent, even for the incidence of non-polarized photons, leading to a finite spin-polarized photocurrent j_x. We examine this magneto-photogalvanic effect and realized that the zero-bias photocurrent dramatically increases for the mid-infrared photoexcitation, pointing to the relevance of surface-state dispersions and the strong influence of bulk-surface scatterings. We also demonstrate that it is critical to precisely control the Fermi energy to observe intrinsic nature of TIs. For example, the photogalvanic current shows a pronounced peak when we tune the Fermi energy across the Dirac cone. If time allows, on-going works on the proximity effects and photocurrent in Rashba semiconductors/Weyl materials will also be presented.

Reference

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