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Spin Texture And Spin Injection In A 3D Topological Insulator

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Abstract

One of the most critical steps towards spin functionalized electronics and optoelectronics is to generate and manipulate spin current in a desirable way. In 3D topological insulators (TIs), a strong spin-orbit interaction and the time-reversal symmetry result in spin-momentum locking of the surface electrons, which leads to a unique surface spin texture and the prospect of generating directional and dissipationless spin current running across the surface that is promising for spintronic applications. However, the metallic nature that is often found to be inherent to many 3D TIs due to residual defects has unfortunately imposed a severe obstacle to controlling surface spin current. As a result, very little experimental work has been done so far on this issue. Moreover, since most of the early studies have been limited to Bi_2Se_3 - a prototypical TI with a rather weak hexagonal warping effect, the contribution of the out-of-plane spin texture to the photocurrent remains elusive so far. In this work, we show that, with circular polarized light, helicity driven photocurrent is obtained in another 3D TI Bi_2Te_3 that exhibits a stronger hexagonal warping effect. We find the helicity-dependent photocurrent to be sensitive to the incident angle of the light, which could be explained within the framework of the circular photo-galvanic effect (CPGE) by taking into account the spin texture of the topological surface state. By correlating the light incident angle and probing surface current directions, we are able to identify photocurrent components associated with the in-plane and out-of-plane spin texture of the TI and thereby directly uncover the impact of the out-of-plane spin texture on surface spin current promoted by the strong hexagonal warping effect. By exploring the out-of-plane spin texture, we demonstrate spin injection from GaAs to TI and its significant contribution to the surface current [1]. We further show that the spin current of TI can be manipulated by the precession of injected electron spins in an external magnetic field. These discoveries pave the way to not only intriguing new physics but also enriched spin functionalities by integrating TI with conventional semiconductors, such that spin-enabled optoelectronic devices may be fabricated in such hybrid structures.

References

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