第51回トポロジカル物質科学セミナー
Topological Materials Science Seminar (51)

Rashba states in topological insulators

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Abstract:

Topological insulators (TIs) are materials that are electrical insulators in the bulk but the surface encompasses conducting states. TIs have attracted enormous attention in the recent past as it was expected to exhibit diverse properties arising out of the topological surface states (TSS). In the early days of TI research, it was assumed that these surface states could support robust spin currents and that a mechanism to manipulate their spin texture would provide significant advances in spintronics technologies. This view has been contested in recent years. It is now understood that the spin texture in TIs is protected by unusually large spin-orbit fields that is virtually impossible to manipulate by electrical means. An alternative is to use the spin transport properties of Rashba surface states (RSS) that co-exist with the TSS. Unlike the TSS, the RSS can be readily manipulated by controlling inversion symmetry breaking at sample surfaces by electric fields. In this lecture, investigations on single crystal and thin film TIs (Bi_2Se_3) will be discussed but emphasis will be given to low temperature electrical transport measurements in gated $BiSbTe_{1.25}Se_{1.75}$/hexagonal-BN van der Waals heterostructure devices. The experiments with electrical gating indicate the presence of Rashba spin-split states confined to the sample surface apart from the usual TSS. While previous photo-emission spectroscopy and STM experiments have observed these states, it has not been possible to unambiguously detect them by electrical means and their electrical transport properties remain largely unknown. It will be shown that these states support high mobility conduction with Hall effect mobilities ~ 200 - 3000 cm^2/V-s that are paradoxically much larger than the mobilities of the topological surface states ~ 300 cm^2/V-s at T = 2 K. The spin-split nature of these states is confirmed by magneto-resistance measurements and reveal multi-channel weak anti-localization. This work shows that Rashba spin split states can be electrically accessed in isolation of competing electronic states in TIs. Unlike the topological surface states that have found little application despite a decade long effort, we propose that the Rashba surface states could have enormous applicability in spintronics technology.

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