复旦大学物理系 物质科学报告

Time: 2:00pm, Tuesday, 2017.11.21

Location：Physics Building, Room 221B

Scanning Tunneling Spectro-microscopic Study on Spintronic Emergent Materials

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We present here the study of scanning tunneling microscopy (STM) with scanning tunneling spectroscopy (STS) on emergent materials with spin characteristics, such as topological insulators (TI), Rashba Semicondutors and hybrids of metal-organic molecules. STS is used to monitor the local electronic structure in nanometer scale for material surface.

The material, exhibiting a giant Rashba effect at the surface and in the bulk, due to the crystal inversion asymmetry, is currently a subject of intense interest for the spintronics community. Unlike previously demonstrated metal surfaces exhibiting a strong Rashba effect, BiTeX-series is a semiconductor, without spin-degenerate carriers at the Fermi level. However, the surface band bending induced by the two possible polar terminations brings either the strongly spin-split conduction or valence band to the Fermi level, making Rashba spin-split electron or hole bands electronically accessible. Using spatially resolved STS across the lateral boundary between the two terminations, a previously speculated p-n junction-like discontinuity in electronic structure at the lateral boundary is confirmed experimentally. [1]

Further technique by observing quasi-particle interference of the band electrons at BiTeX semiconductor, a hallmark of spin-momentum-locked helical spin texture, beyond only the topological insulators. has been used for extracting the information on electronic structure with spin characteristics. [2] As the second example, in examining the quasiparticle scattering behavior at the surface of the Dirac semimetal ZrSiS [3], two distinct interference patterns have been observed selectively by the scattering around the impurity site of Zr and S of crystal lattice. Further investigation with help of the first principle calculation can distinguish the interference patterns by the subset bands with various magnetic quantum numbers, indicating a strong band-selection behavior in QPI. The findings of both examples promises to spur new investigation into the quasiparticle scattering process itself, and ultimately inform atomic scale engineering of quantum electronic transport with band characteristics.

Another interesting finding in TI system will be also addressed.

Formation of Fe-PTCDA (perylene-3,4,9,10-tetracarboxylic-3,4,9,10-dianhydride) hybrids on the Bi_2Se_3 surface can reveal the functionality of PTCDA to prevent dopant disturbances in the topological surface state, providing an effective alternative for interface designs of realistic TI devices. [4,5] Spin-Polarized STM also observed the spin-response of the organic molecules deposited on magnetic Co islands, which affects the molecular symmetry. [6]

Short Bio

Prof. Minn-Tsong Lin is Distinguished Professor at Department of Physics, Taiwan University. He obtained his bachelors degree from Taiwan University, Diplom-Phyisker (master degree) from University of Heidelberg, and his Ph.D. from Department of Physics, University of Halle, with the thesis supervised at Max-Planck-Institute of Microstructure Physics, Germany. Prof. Lin was studying the complex interplay among the electronic and structural factors governing the nanomagnetism and spin-dependent transport in ultrathin magnetic films and (organic) spintronic as well as nanomagnetic systems. Recently, he focuses his research on spintronics with emergent materials, such as topological insulator and Rashba-semiconductor in both spectro-microscopic and transport aspects. He is now also serving as Associate Editor of Applied Physics Letters and the President of the Physical Society of Taiwan.