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Study of the Topological-insulator-based Topological Superconductors[1]

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Three-dimensional topological insulators possess nontrivial spin-momentum locked surface states under the protection of time-reversal symmetry. The interplay between topological order and superconductivity can lead to topological superconducting state. In this talk, I will discuss our recent progress in topological-insulator-based topological superconductors. Using molecular beam epitaxy (MBE) method, we succeeded in fabricating very high quality TI/s-wave superconductor heterostructure by growing topological insulator thin films on the conventional superconductor niobium diselenide ($NbSe_2$) substrate. Using low temperature scanning tunneling microscopy/spectroscopy (STM/STS) and angle-resolved photoemission spectroscopy (ARPES), we systematically studied its electronic structure and superconducting behavior. Through superconducting proximity effect, coexistence of Cooper pairs and topological surface states on the surface of topological insulator film was realized. By exploring the superconducting vortex core state as the function of film thickness, existing of nontrivial superconducting state on the TI's surface was proposed. Our topological insulator/superconductor heterostructure may host single zero-energy Majorana mode in the vortex core. In addition, I will also discuss STM and ARPES studies on the recently discovered superconducting Sr-doped Bi_2Se_3 bulk crystals. Our results suggest that Sr-doped Bi_2Se_3 could be an excellent candidate for exploring topological superconducting states.

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