Ambient-stable transition-metal dichalcogenides hosting type-II Dirac fermions and their applications in catalysis, nanoelectronics, and plasmonics

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Abstract

Among transition-metal dichalcogenides, those exhibiting Dirac/Weyl fermions represent an intriguing platform for both fundamental science and technological applications. In this talk, I will discuss main features of physicochemical properties of MTe_2 (M=Pt, Pd, Ni), combining type-II Dirac fermions and spin-polarized topological surface states, and their applications in catalysis, nanoelectronics and plasmonics.

By combining surface-science experiments and density functional theory, we demonstrated that the pristine surface of MTe_2 is chemically inert toward the most common ambient gases (oxygen and water) and stable in air [1-3]. The measured photocurrent of MTe_2-based optoelectronic devices showed negligible changes (below 4 %) in a timescale of one month, thus excluding the need of encapsulation in the nanofabrication process. Remarkably, the responsivity of a MTe_2-based millimeter-wave receiver was one order of magnitude times higher than similar devices based on black phosphorus and graphene in the same operational conditions. Moreover, we fabricated ultrasensitive Terahertz (THz) photodetectors based on MTe_2 and their heterostructures with graphene, also enabling large-area, fast-scan (~10 ms) imaging experiments with 0.3 THz light [4-6], validating the potential associated to the control of nonequilibrium gapless topological states.

Finally, we identified the collective electronic excitations of type-II Dirac fermions (3D Dirac plasmons) in MTe_2 single crystals [7, 8], with observed plasmon energies in the near-infrared and visible.

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