Irradiation induced doping of topological insulators

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Native defects retained in the crystal in the growth process can be determinant for their physical properties. In particular vacancies are in most cases electrically active, providing free charge to the system and acting as scattering centers. At room temperature and below their concentration is metastable and determined by migration energy. Irradiation with energetic particles allows controlled introduction of native defects and tuning of electronic transport properties of materials. This procedure can be used to turn the material to the charge neutrality state in the bulk and control metal to insulator transition.

In my presentation, I will review the methods of particle irradiation focusing on low temperature electron irradiation producing vacancy – interstitial (Frenkel) pairs and on swift heavy ion irradiation (in GeV range) leading to local amorphisation along particle trajectory.

In the second part of my talk, I will give the examples of use of particle irradiation for control of mean free path of carriers and for test of mechanisms of superconducting pairing mechanism.

To illustrate doping effect I will present the results of ongoing research on the tuning by energetic particle irradiation of electronic transport properties of topological insulators of two families: (1) time reversal symmetry protected Bi_2Te_3 and Bi_2Se_3 and (2) crystal symmetry protected $PbSn_xSe_{1-x}$. Two-step procedure consisting of irradiation at low temperature by 2.5 MeV electrons followed by appropriate annealing allows the reduction of the bulk conduction to the point that surface channel become dominant. This is demonstrated by the measurements of magneto resistance and of it angular dependence. Angular Resolved Photoemission Spectroscopy performed on the irradiated crystals proves the persistence of Dirac cone feature and immunity of the topologically protected states to the irradiation-induced disorder.