Electrical and magnetic properties of magnetic topological materials of the $(Bi,Sb)_2(Te,Se)_3$ family

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Topological insulators are at the center of interest of the condensed matter physics due to their fundamental properties and possible application in modern electronics. The topological gapless surface states are protected by the time-reversal symmetry and can be manipulated (the gap at the Dirac point can be opened and tuned, spin texture can be manipulated) by introducing a time-reversal-breaking perturbation (e.g., through doping with elements comprising magnetic moments).

In this work, we present our experience in the control of electrical and magnetic properties of materials from the $(Bi,Sb)_2(Te,Se)_3$ family, doped with Mn. In pure Bi_2Te_3 the type of electrical conductivity can be controlled by adjusting the composition of elements during the growth process [1]. The stoichiometric and bismuth rich melts crystallize into p-type Bi_2Te_3 whereas tellurium rich melts give the n-type Bi_2Te_3. This relation is no longer valid when manganese is added to the system. While the presence of Mn in the stoichiometric Bi_2Te_3 results in the p-type conductivity with concentration of holes up to 10^{20} cm^{-3}, the excess of Te in the melt does not result in the n-type material. The obtained crystals are p-type with concentration of 10^{19}-10^{20} cm^{-3}. Moreover, the n-type conductivity with electron concentration of 10^{20} cm^{-3} is observed in crystals obtained from Bi-rich melt.

The presence of Mn in materials of the $(Bi,Sb)_2(Te,Se)_3$ family affects their magnetic properties. We have observed three ferromagnetic phases with phase transition temperatures around 5 K, 10-12 K, and 24 K, respectively. The ferromagnetic phase with the phase transition temperature of 24 K was observed in binary Bi_2Te_3 as well as in $Bi_{2-x}Sb_xTe_{3-y}Se_y$, both doped with Mn. Anomalous Hall effect was observed below 15 K. At 4 K two overlapping hysteresis were found.

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