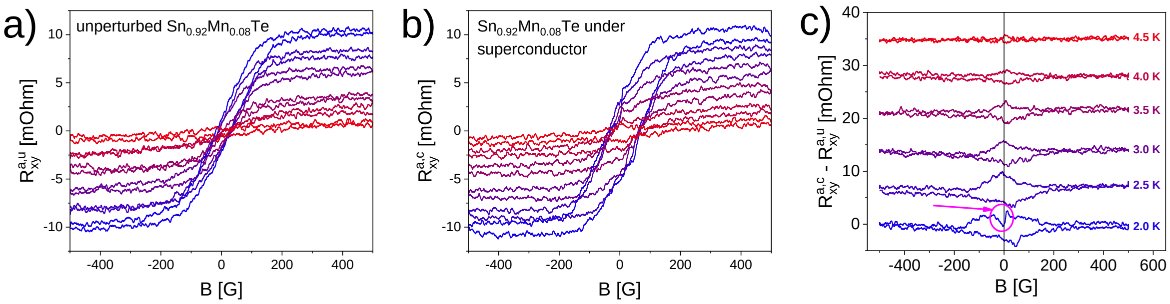
Ferromagnetic topological crystalline insulator $Sn_{1-x}Mn_xTe$ in an inhomogeneous magnetic field

A. Kazakov[1], V.V. Volobuev[1], M. Chojnacki[1,2], T. Wojciechowski[1,2], T. Wojtowicz[1]

[1] *International Research Centre MagTop, Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, 02-668 Warsaw, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, 02-668 Warsaw, Poland*

The archetypical topological crystalline insulator (TCI) SnTe doped with manganese becomes ferromagnetic at low temperatures. In the ferromagnetic state, there is an additional contribution to the Hall resistance, the anomalous Hall effect (AHE, R_{xy}^{a}), which depends on the magnetization of the material. An inhomogeneous external magnetic field modifies the spin texture of the magnetic material and can lead to the so-called topological Hall effect. The inhomogeneous magnetic field can be created by placing magnetic or superconducting (SC) structures on top of the layer under investigation. In the case of an SC layer made of type II superconductor, the inhomogeneity is caused by a vortex lattice formed in the magnetic field.

Previously, the effect of an inhomogeneous magnetic field on magnetotransport was studied mainly in non-magnetic materials. In this work, we extend this approach to ferromagnetic topological insulators. We grew 30-50 nm thin layers of $Sn_{1-x}Mn_xTe$ with a Curie temperature of around 5 K by molecular beam epitaxy. These layers were then processed in two-section Hallbars. One of the sections was covered with a SC Nb separated from the epilayer by a thin (~20 nm) oxide layer. The other section of the Hall bar was left bare for comparison. The influence of the SC layer on the magnetotransport of TCI ferromagnet was probed by measuring AHE in the $Sn_{1-x}Mn_xTe$ layer. We found that the AHE hysteresis loop in the covered area, $R_{xy}^{a,c}$, was wider than in the uncovered area, $R_{xy}^{a,u}$, as seen in Fig. a,b. This widening is caused by the Meissner effect and is a direct consequence of the modulation of the magnetic field by the SC layer. The difference between AHE curves in the uncovered and covered areas gives profiles that strongly resemble the magnetization curves of a superconductor (Fig. c). We also observed that additional peaks appear on a $R_{xy}^{a,g} - R_{xy}^{a,u}$ curve, indicating the emergence of the topological Hall effect caused by a SC flux inhomogeneity.



(a,b) AHE contribution to the Hall resistance R_{xy}^{a} in $Sn_{0.92}Mn_{0.08}Te$ measured as a function of the magnetic field B for various temperatures. AHE hysteresis in the Hallbar under the SC is much wider than in the bare epilayer. (c) The difference between AHE curves in covered and uncovered areas ($R_{xy}^{a,g} - R_{xy}^{a,u}$resembles magnetization hysteresis. However, under certain conditions additional spike (marked with a magenta circle) appears, which can be considered as a signature of the topological Hall effect.

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