Magnetoelectric and structural properties of 3D topological insulator Bi_2Te_3 doped with Mn

J. Sitnicka,[1] M. Konczykowski,[2] A. Reszka,[3] P. Skupiński,[3] K. Grasza,[3]
J. Borysiuk,[1] K. Sobczak,[4] A. Avdonin,[3] I. Fedorchenko,[5] M. Kamińska,[1] Lia Krusin-Elbaum,[6]
A. Wołoś[1]

[1] *Faculty of Physics, University of Warsaw, ul. Pasteura 5, 02-093 Warsaw, Poland*
[2] *Laboratoire des Solides Irradies, Ecole Polytechnique, 91 128 Palaiseau, France*
[3] *Institute of Physics Polish Academy of Sciences, al. Lotników 32/46, 02-668 Warsaw, Poland*
[4] *Faculty of Chemistry, Biological and Chemical Research Centre, University of Warsaw, Żwirki i Wigury 101, 02-089 Warsaw, Poland*
[5] *Kurnakov Institute of General and Inorganic Chemistry, 119991 Moscow, Russia*
[6] *Department of Physics, The City College of New York, CUNY, New York, New York 10031, USA*

First observation of the Quantum Anomalous Hall Effect (QAHE) in 2013 [1] triggered investigations of materials meeting physical criteria for this effect: inverted band structure and ferromagnetism with out of plane easy axis – ferromagnetic topological insulators (TI). Once time reversal symmetry is broken, the two-dimensional surface of a three-dimensional TI always obtains a half quantized Hall conductance. QAHE was observed for the first time in $Cr_{0.15}(Bi_{0.1}Sb_{0.9})_{1.85}Te_3$, and later also in V-doped TI.

In this work, we examined another candidate for QAHE material, the Bi_2Te_3 doped with 2% of Mn atoms. We correlate magnetic and electric properties with results of structural studies. For precise determination of atomic arrangement of Mn ions in Bi_2Te_3 structure we applied the Transmission Electron Microscopy imaging and the Energy-Dispersive X-ray spectroscopy microanalysis (EDX). Chemical microanalysis EDX shows that Mn is incorporated into Bi_2Te_3 matrix in two ways – one as a substitute of Bi atoms and second as an element of Bi_2MnTe_4 compound, forming a superlattice with $(Bi,Mn)_2Te_3$. Ferromagnetic Resonance Measurements (FMR) were performed at different temperatures and versus the angle between the external magnetic field and the Bi_2Te_3 c-axis. Well above 15 K, single resonance line is present. The g-factor determined for the external magnetic field oriented parallel and perpendicular to the Bi_2Te_3 agrees within the experimental error to the g-factor determined earlier for paramagnetic Mn^{2+} substituting Bi site in Bi_2Te_3 [2]. Below 15 K the spectrum develops strong anisotropy characteristic for ferromagnetic resonance. In ferromagnetic regime the single resonance line splits into two lines with different widths which we correlate to $(Bi,Mn)_2Te_3$ and the superlattice regions, respectively. Hall resistance measurements reveal anomalous Hall behavior below 15 K, consistent with FMR measurements. The easy axis for magnetization is out of plane.

We would like to acknowledge National Science Center, Poland, grant no 2016/21/B/ST3/02565.

[1] Cui-Zhu Chang et al., Science 340, 167 (2013).
[2] S. Zimmermann, F. Steckel, C. Hess, H. W. Ji, Y. S. Hor, R. J. Cava, B. Buchner, and V. Kataev, Phys. Rev. B 94, 125205 (2016).