Ultrathin films of topological insulator Bi2Te3 – new properties and limitations of technology

M.Weis[1,2], B.Wilk[1,2], K.Balin[1], G.Vaudel[2], A.Bulou[2], B. Arnaud[2], J.Szade[1], P.Ruello[2]
[1.] *A. Chelkowski Institute of Phvscis and Silesian Center for Education and Interdisciplinary Research, 75 Putku Piechoty 1A, Chorzów, Poland*
[2.] *lnstitut des Molécules et Matériaux du Mans, UMR CNRS 6283, Université du Maine, 72085 Le Mans, France*

Topological insulators (TI) are as one of the key elements for new generation electronics and spintronics, charge-to-spin current conversion gates or as Dirac fermions based nanometer scale Schottky diodes. When reduced just to few single layers, TI begin to show a dramatic quantum size effect that change the electronic structure and in consequence dynamics of carriers and phonons.

In order to describe those behaviors we used advanced high-vacuum cluster with MBE in order to grow wedge-like sample of Bi_2Te_3 with thicknesses ranging from 3 up to 12 nm. The sample was grown on muscovite mica substrate in the co-deposition mode as described in our previous work [2]. The monocrystalline structure of the film was confirmed with both LEED and RHEED measurements, and the complementary studies of electronic structure focused on the analysis of the valence band and Bi4f, Te3d and O1s core levels assured the correct stoichiometry. The femtosecond pump-probe spectrosopy [3] has been used to excite the hot carriers and generate coherent optical phonons within Bi_2Te_3 nanostructures and observed it in time domain.

We present a broad investigation of high quality monocrystllaine layers of Bi_2Te_3, in which we observe the existence of a critical thickness around ~ 6 nm, below which spectacular reduction of the carrier relaxation time is observed. In addition, we also evidence an A1g optical phonon mode softening together with the appearance of a thickness dependence of the photo induced coherent acoustic phonon signals. This drastic evolution of the carriers and phonon dynamics might be due to an important electron-phonon coupling evolution related with the quantum confinement [4]. These properties have to be taken into account for future Tls-based spintronic devices.

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