Local conductance and ultrafast dynamics of MBE grown Bi_2Te_3 films

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Topological insulators (TI) are a new class of materials with semiconducting bulk solid while conducting on the surface. The surface Dirac electronic states exhibit natural spin-polarized current and appear to be protected against backward non-magnetic scattering. This makes them very attractive in applications for next generation spintronic devices [1].
The spin-orbit and electron-phonon coupling effects play a pivotal role in the transport properties of surface and bulk electrons. The detection and control of spin-momentum-locking of the surface states, as well as understanding the electron dynamics are the crucial problems determining the future applications.

In this work we studied thin films of Bi_2Te_3 belonging to the group of three-dimensional TIs. The films were grown on Si(100) or mica (muscovite) substrates by thermal evaporation with the use of Molecular Beam Epitaxy (MBE). For the films grown on Si polycrystalline structure was found while the deposition on the mica substrate lead to the formation of high quality single crystal films with the thickness in the range 4-20 nm [2-4].
The correlations between structural properties and morphology of the deposited films and their local electrical conductivity were studied with the use of AFM microscopy with the conducting tip (LC AFM) [3]. Application of LC-AFM allowed us to show the extremely high conductivity (very high contact currents) and metallic behavior (linear I–V curves) of the Bi_2Te_3 film surface, which most likely is an effect of the presence of the Dirac surface states. Moreover, we were able to localize small regions with reduced conductance, which were attributed to the local changes of the electronic structure caused by various defects.

By applying femtosecond pump-probe optical spectroscopy we demonstrated that it is possible to generate coherent optical phonons in Bi-Te nanostructures both in poly and single crystalline samples [4]. We show the effect of critical thickness of the film limiting the generation of the optical phonons. A new insights on the out-of-equilibrium electron- phonon coupling and phonons dynamics in confined TI was achieved. Additionally, by testing the effect of cap layer we were able to detect a strong dependence of the electronic excitation relaxation time on the element forming the overlayer.

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