Charge transport in topological insulator nanostructures

Gunta Kunakova
University of Latvia

In 3D Topological Insulators, due to the strong spin-orbit interaction, spin of the surface state electrons is locked perpendicularly to the momentum, and transport via the surface states is protected against backscattering from non-magnetic impurities. Exotic properties of the surface states in topological insulators are of great fundamental research interest and are attractive for applications in spintronics and quantum computing. Practically access and exploitation of the surface state charge transport is challenging to access due to the large contribution of the material bulk conductance, and one of the approaches is to use nanomaterials possessing large surface to volume ratio.

Magnetotransport measurements were conducted at a base temperature of 2K, in a Physical Property Measurement System, equipped with a 9T magnet.

Analysis of Hall effect measurements and Shubnikov-de Haas quantum oscillations confirms presence of topological surface states. Additional band of high carrier density is identified and originates from an accumulation layer, formed at the nanoribbon/substrate interface. Charge transport exclusively via the surface states is achieved by gate-tuning the Fermi energy through the Dirac point. Alternatively, formation of trivial accumulation layers interfering access the surface state transport can be mitigated in all-around encapsulated nanoribbons [2-4].

We conclude that topological insulator Bi_2Se_3 nanoribbons hold great promise for accessing new properties arising from the topologically protected surface states.

References

[1] Nanoscale, 7, 38, 15935, 2015
[2] Nanoscale, 10, 19595, 2018
[3] Phys. Rev. Appl., 16, 024038, 2021
[4] Nanomaterials, 12, 768, 2022