Terahertz conductivity of interface-dominated nanograined Bi_2Te_3

Jeongwoo Han[1]
Sepideh Izadi[2,3], Sarah Salloum[4], Stephan Schulz[4], Gabi Schierning[2], and Martin Mittendorff[1]
[1]*Department of Physics, University of Duisburg-Essen, 47057, Duisburg, Germany*
[2]*Department of Physics, Bielefeld University, 33615, Bielefeld, Germany*
[3]*Leibniz IFW Dresden, Institute for Metallic Materials, 01069, Dresden, Germany*
[4]*Department of Chemistry, University of Duisburg-Essen, 45141, Essen, Germany*
jeong.han@uni-due.de

Topological insulators (TIs) are a state of matter characterized by trivial bands for the bulk and Dirac states at the surface [1]. One of their most touted properties is the spin-momentum locking in the topologically protected surface states, suppressing backscattering via non-magnetic defects thereby providing ultra-high mobility [2]. However, in extended crystals, bulk carriers usually dominate over surface carriers, thus, it is difficult to observe their contribution in TIs despite their intriguing properties [3]. To increase the contribution of the surface carriers, macroscopic samples of Bi_2Te_3 composed of nanoparticles offer a surface-to-volume ratio of approximately $2x10^5$ cm^2/cm^3. Here, we present temperature-dependent (0 to 300 K) terahertz (THz) spectroscopy of nanograined bulk Bi_2Te_3. The hot-pressed pellets have a diameter of 5 mm (cf. Fig. 1(a)) and are kept in an optical cryostat. In Fig. 1(b) the reflectivity is plotted as a function of the frequency at 4 K.
To further analyse the measured reflectivity, we model the combined conductivity of surface and bulk carriers. We consider three different contribution to the overall conduction, namely Drude conductivity from the surface σ_S and the bulk σ_B carriers as well as plasmonic response σ_P (see Fig. 1(b)). The latter is attributed to collective oscillations of high mobility surface carriers that are confined in micrometer sized grains of Bi_2Te_3 (comprised of multiple nanoparticles). Using a combination of these three contributions, we extract the mobility of surface carriers as a function of temperature, which turns out as high as 1.2×10^4 ($3x10^3$) $cm^2V^{-1}s^{-1}$ at 4 (300) K, proving the high quality of the nanoparticles. Importantly, we find that the surface carriers significantly contribute to the optical conductivity even at room temperature, which is essential to make use of the high mobility surface carrier in real-world devices.

References

[1] Zhang, H *et al*, Nat. Phys., **5** (2009) 438-442.
[2] Roushan, P *et al.* Nature, **460** (2009) 1106-1109.
[3] Ando, Y *et al*. J. Phys. Soc. Japan, **82** (2013) 1-32.

Figures

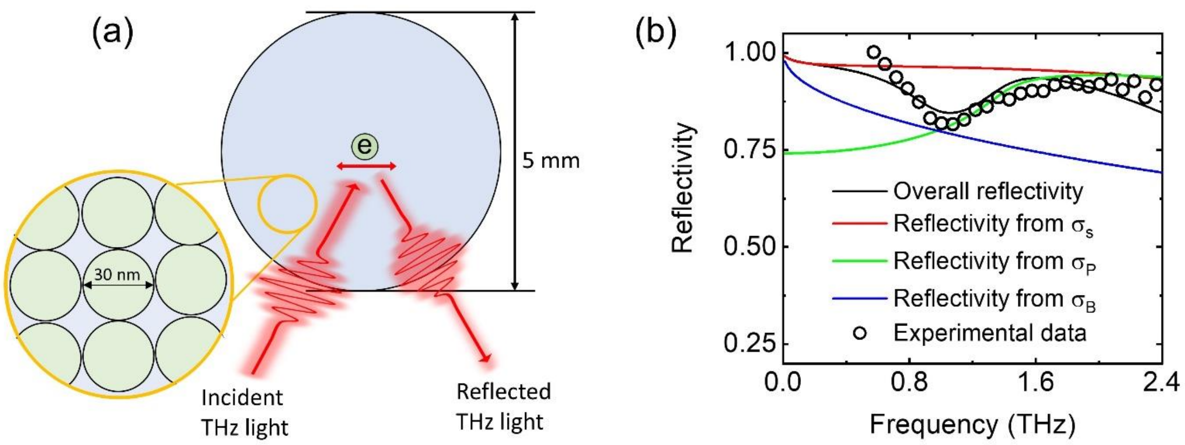

Figure 1: (a) Sketch of the measurements of nanograined Bi_2Te_3. (b) Measured and calculated reflectivity as a function of the frequency at a temperature of 4 K.