Doping-level dependent polarity reversal of terahertz photo-conductance in topological insulators.

Seungmin Lee1,* Sangwan Sim1, Jisoo Moon2, Nikesh Koirala2, Soonyoung Cha1, Hoseung Shin1, Suhyun Park1, Seongshik Oh2, and Hyunyong Choi1

1School of Electrical and Electronic Engineering, Yonsei University, Seoul 120-749, Korea
2Department of Physics and Astronomy, Rutgers, The State University of New Jersey, Piscataway, NJ 08854, USA

hychoi@yonsei.ac.kr

Topological insulator (TI) is a new quantum material, where the insulating bulk state and Dirac-like topological surface state (TSS) coexist [1]. Despite its novel topological property, however, the screened TSS response by the bulk states causes challenges to apply in optoelectronics and electronics. Recently, a molecular beam epitaxy (MBE) technique enables to grow the bulk insulating Bi2Se3 on a buffer layer, which effectively eliminates the bulk screening effect [2]. Furthermore, it is also possible to change the doping level below/above the Dirac point, by which one can investigate both the carrier dynamics of TSS and the effect of bulk states.

In this work, we show that the photoinduced terahertz responses are significantly different depending on the fermi level of Bi2Se3 TI. With near-IR pump (1.03 eV) and terahertz spectroscopy [Fig. 1(a)], we discovered that the terahertz photo-conductance response is opposite between the bulk insulating and the p-type Bi2Se3 after pump-probe delay of 10 ps [see Fig. 1(b) and (c)]. In bulk insulating Bi2Se3, the negative photo-conductance originates from the Dirac surface metallic property (blue line in Fig. 2(b)) [3]. However, in p-type Bi2Se3, the TSS negative metallic response is completely masked by the positive response of the bulk (red line in Fig. 2(b)). Our work highlights that the dynamic interplay between the photo-induced Drude spectral weight and the scattering rate plays an important role in understanding the low-energy photoresponse of TI.

References

![Figures](image)

Figure 1: Transient THz responses at 77 K. (a) Schematic of Near IR-pump THz-probe experiment. (b) Schematic band structure for bulk insulating and P – type Bi2Se3. (c) Normalized ΔEf as a function of pump-probe time delay (Δt).

![Figure 2](image)

Figure 2: Complex THz sheet photo-conductance of bulk insulating and P-type Bi2Se3 at Δt = 2ps (a) and Δt = 500ps (b).