Ultrafast Dirac Plasmon Dynamics in 3D Topological Insulators

***Hyunyong Choi*[1*]**

[1]*Department Physics and Astronomy, and Institute of Applied Physics, Seoul National University, Seoul, 08826, Korea*

*E-mail: hy.choi@snu.ac.kr

Ultrafast optical control of plasmons provides a potential route towards novel Dirac carrier physics in three-dimensional (3D) topological insulators (TIs). Because of the unique coexistence of the semiconductor-like bulk state and metallic Dirac states on surfaces, the 3D TIs are novel electronic systems for the plasmon engineering. Notably, the two-dimensional (2D) Dirac plasmon in the topological surface state of the 3D TI exhibit the ultrafast thermalization between electron and phonon, revealing distinct THz spectra compared to the equilibrium state. Based on the electron-phonon interaction in the 3D topological insulator Bi_2Se_3, we have investigated the control of surface Dirac plasmon using an ultra-short optical excitation with a peculiarly stiffened phonon linewidth while exceeding 2,400% of modulation depth [1].

We have found interesting time-dependent dynamics of the Dirac plasmon and the phonon broadening /stiffening, in which a dynamic quantum-phase transition was observed as the Dirac plasmon resonance shifts across the TI phonon resonance. Moreover, the suppression of electronic screening effect on the phonon-polariton was revealed as an origin of the unexpected stiffening of the phonon linewidth [2].

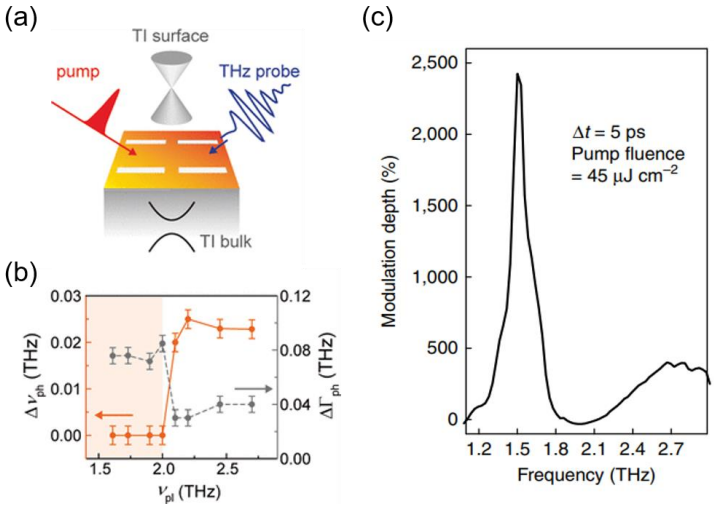

Figure 1: (a) Optical pump THz probe on TI slits. **(b)** The change in phonon frequency $\Delta\nu_{ph}$ and phonon width $\Delta\Gamma$ as a function of plasmon frequency ν_{pl}. **(c)** Frequency-domain transient view of THz modulation depth under the presence of optical pump with 5 ps of time delay Δt.

References:

[1] C. In *et al*., Control over electron-phonon interaction by Dirac plasmon engineering in the Bi_2Se_3 topological insulator, *Nano Letters* **18** 734-739, 2018

[2] S. Sim *et al*., Ultra-high modulation depth exceeding 2,400% in optically controlled topological surface plasmons, *Nat. Commun.* **6** 9814, 2015