Carrier dynamics in topological insulators probed by optical pump probe STM

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$BiSbTeSe_2$ and Bi_2Te_2Se are known to exhibit ideal characteristics of 3D topological insulators(TI), such that they exhibits surface dominant transports due to its bulk insulating properties and their Dirac point energy are tunable within the bulk band gap by changing their alloy composition. Such bulk insulating property will open up a new possibility to control Dirac surface state by optical excitation. For example, a chemical potential of the Dirac surface state can be controlled by a surface photovoltage[1].

In this study, we performed optical pump STM experiment to evaluate the carrier dynamics at the Dirac surface state on $BiSbTeSe_2$ and Bi_2Te_2Se using LT-STM operated at 2K. The Crystal structure of Bi_2Te_2Se is shown in fig.a, a hexagonal crystal structure consisting of five atomic layers along c axis. STM image obtained on BTS surface is shown in fig.b. Atomic scale topographic height variation arises from inhomogeneity of electronic structure due to alloy. To study the dynamics of optically excited Dirac surface state, we carried out optical pump probe STM experiment. A sample surface was excited by a sequence of laser-pulse pairs to generate photocarriers in the sample and photo-induced tunneling current was measured as a function of delay time between pulse pair. Time resolved tunneling current spectrum (fig.3) shows single exponential decay which represent the surface carrier lifetime is 110ns. The value is extraordinary longer than the other TIs.

[1] M. Neupane *et al.*, PRL, **115**, 116801 (2015)

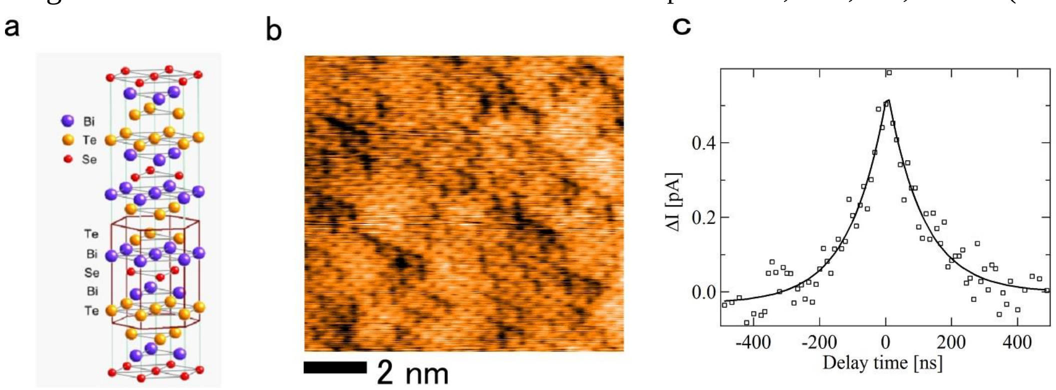

Fig.(a) Crystal structure of Bi_2Te_2Se (b) STM image of Bi_2Te_2Se surface (c) Time resolved tunneling current spectrum