Terahertz magneto-photocurrents in the topological insulator Bi_2Se_3

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Femtosecond laser excitation can drive ultrafast photocurrents in topological insulators (TIs) such as Bi_2Se_3 (Fig. 1a). The photocurrent can be monitored by detection the terahertz (THz) radiation it emits [1], thereby providing insights into the current generation and relaxation [1]. Application of a static magnetic field $\boldsymbol{B}$ was reported to modify the photocurrent response on nanosecond time scales [2].

Here, we report THz emission from 30-quintuple-layers (QL) of Bi_2Se_3 thin films by applying a field of $|\boldsymbol{B}| = 0.3$ T parallel to the film plane (Fig. 1a). Figure 2b shows that the $\boldsymbol{B}$-induced THz photocurrent signal ΔS_B and the residual THz signal $S(0)$ for $\boldsymbol{B} = 0$ T exhibit different THz waveforms. In addition, we observe a strong reduction of the ΔS_B amplitude as an increasing fraction x of bismuth is substituted by indium (Fig. 1c). According to ref. [3-5], an increase of x reduces the spin-orbit coupling strength of $(Bi_{1-x}In_x)_2Se_3$ and eventually removes the Dirac surface state at a critical concentration of $x \approx 0.07$. Therefore, the suppressed ΔS_B signal of $(Bi_{1-x}In_x)_2Se_3$ for $x > 0.07$ (Fig. 1c) suggests that the Dirac surface state and the spin-momentum locking are critical to the emergence of the observed THz magneto-photocurrent. The time-dependence of the photocurrent will be extracted, and possible interpretations discussed.

References

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Figures

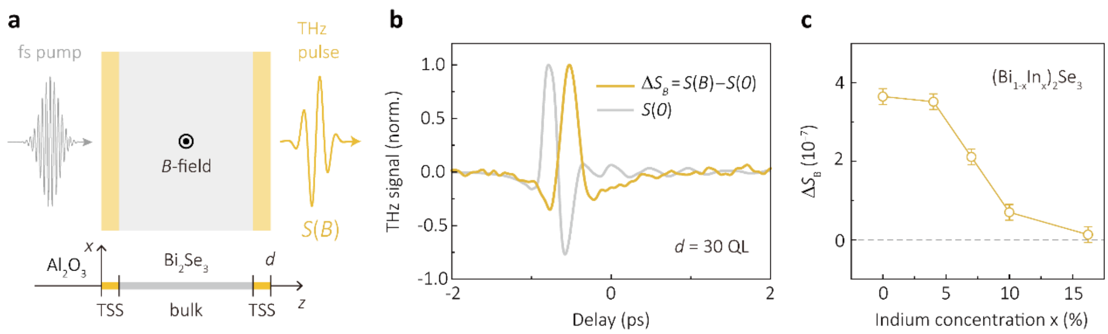

Figure 1: (a) THz emission spectroscopy of Bi_2Se_3 thin films with thickness *d*. The static magnetic field $\boldsymbol{B}$ is applied parallel to the film plane. A femtosecond (fs) pump pulse is incident from the Al_2O_3 substrate and triggers a photocurrent that gives rise to the emission of a THz electromagnetic pulse. (b) Waveforms of the $\boldsymbol{B}$-induced THz signal ΔS_B and the residual THz signal $S(0)$, normalized to their maxima. (c) Peak values of ΔS_B of $(Bi_{1-x}In_x)_2Se_3$ as a function of the indium concentration x.