Topological Dirac semi-metals as novel, optically-switchable, helicity-dependent terahertz sources

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Abstract— **The generation and control of terahertz pulses is vital for realizing the potential of terahertz radiation in several sectors, including 6G communication, security and imaging. In this work, we present the topological Dirac semi-metal – cadmium arsenide – as a novel helicity-dependent terahertz source. We show that both broadband (single-cycle) and narrowband (multi-cycle) terahertz pulses upon near-infrared photoexcitation at oblique incidence. By varying the incident angle of the photoexcitation pulse, control of the emission frequency can also be achieved, providing a candidate for tuneable narrowband terahertz source.**

I. Introduction

Terahertz (THz) pulses play a key role in several applications. However, to fully exploit the potential of THz pulses for fundamental materials research and development of coherent THz optoelectronic devices, control of emission frequency and polarization is required. Topological materials have recently emerged as promising candidates for polarization control across the THz range. Helicity-dependent photocurrent and subsequent THz emission has been observed in both Weyl semi-metals and topological insulators[1-3]. However, to our knowledge, helicity-dependent photocurrents and their corresponding THz emission have not yet been observed in Dirac semi-metals (DSMs). In this work, we present the DSM Cd_3As_2 as a novel THz source. We demonstrate THz emission from both a centrosymmetric Cd_3As_2 single crystal and non-centrosymmetric Cd_3As_2 nanowire ensemble[4] and examine its dependence on the sample azimuthal angle, polarization and incident angle of the optical NIR photoexcitation pulse.

II. Results

The Cd_3As_2 samples were both photoexcited with 1.55 eV optical pulses and the subsequent THz emission was measured via electro-optic sampling in a 1 mm ZnTe crystal. To determine the mechanisms responsible for THz generation in these DSM samples, we measure the THz emission at normal incidence. as a function of photoexcitation fluence, azimuthal angle dependence (sample rotation) and degree of circular polarization of the NIR photoexcitation pulse. For both samples, we observe a linear dependence on photoexcitation fluence and 6-fold symmetry in the azimuthal dependence. A maximum and minimum in the THz emission is observed for excitation with NIR pulses with linear and circular polarization respectively. This cos 4ϕ periodicity of the measured polarization dependence demonstrates that the observed THz radiation arises predominantly from helicity-independent photocurrents at normal incidence. However, at oblique incidence, helicity-dependent THz emission is observed. A

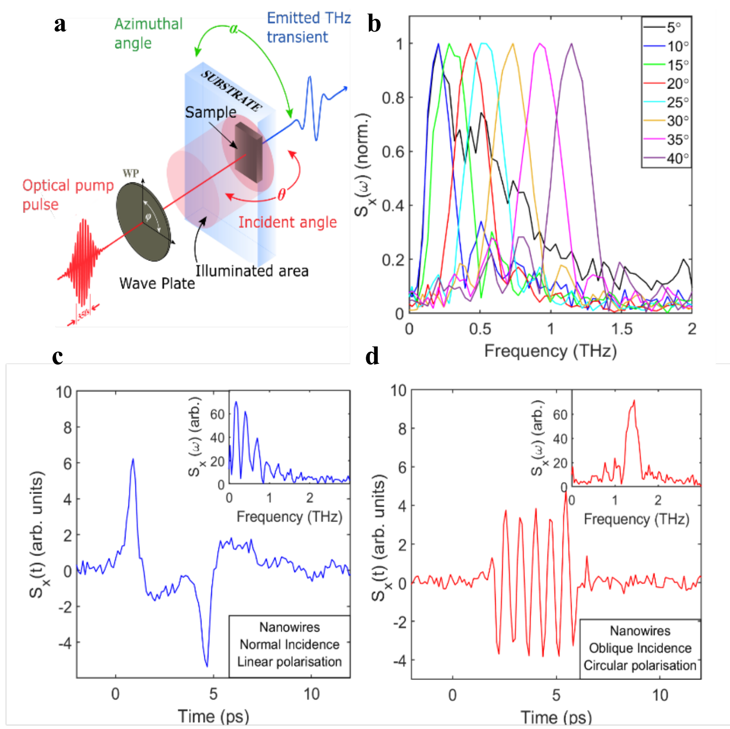

Fig. 1. a) Schematic diagram of experimental setup. b) Emitted THz spectrum for Cd_3As_2 nanowire ensemble when photoexcited by NIR pulses with circular polarization at varying incident angles. Emitted THz transient and spectrum (inset) for the nanowire ensemble when photoexcited at c) normal incidence with linearly-polarized NIR pulses and d) oblique incidence (45 degrees) with circularly-polarized NIR pulses.

large narrowband THz emission is observed when the Cd_3As_2 samples are photoexcited with NIR pulses with circular polarization. The polarity of the emitted signal changes with opposing helicity and between positive and negative incident angles – a key feature of CPGE. By varying the incident angle of the circularly-polarized photoexcitation pulse, the emission frequency can also be tuned within the THz range.

Conclusions

We demonstrate helicity-dependent THz emission in a single crystal and nanowire ensemble of the DSM Cd_3As_2. We demonstrate optical switching between broadband and narrowband THz emission by varying the polarization of NIR photoexcitation pulses.

References

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