A Novel THz Electromagnetic Interference Shielding Material: 2D $Ti_3C_2T_y$ MXene

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***Abstract*—Metallic 2D $Ti_3C_2T_y$ MXene shows high electrical conductivity and strong absorption of electromagnetic radiation in the THz frequency range. We demonstrate that optical pulses (400nm and 800nm) induce transient broadband THz transparency in this MXene, which lasts for nanoseconds and is independent of temperature from 95 to 290 K. This optically controlled THz electromagnetic interference shielding material could be exploited in future THz communication systems.**

I. INTRODUCTION

DUE to its high conductivity, charge storage capacity, flexibility, and saturable optical absorption, $Ti_3C_2T_y$ MXene has shown promise for applications in supercapacitors, transparent electrodes, optical diodes and others [1]. It has also demonstrated electromagnetic interference (EMI) shielding efficiency in the 8-18 GHz frequency range that is superior to graphene, graphite, and copper and aluminum foils [2]. Increasing demand for higher bandwidth and rates of data transfer is making higher frequency ranges more attractive for communication, creating a need for EMI shielding in the THz range.

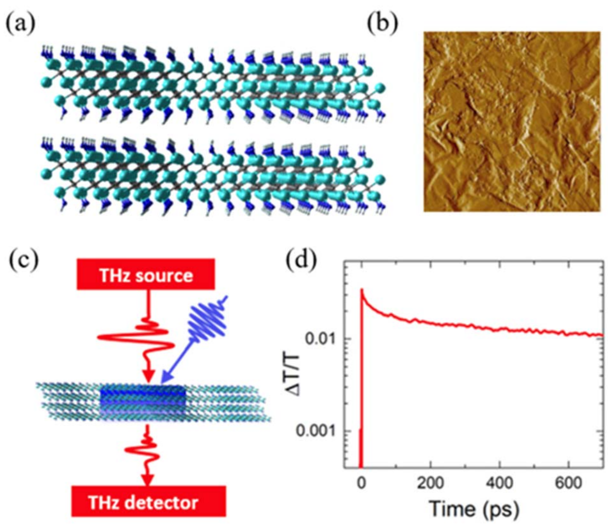

Fig. 1. (a) Structure of a $Ti_3C_2T_y$ layer: five atomic layer thick Ti_3C_2 cores of individual flakes are terminated by -OH, -F, =O groups, (b) 2μm by 2μm AFM micrograph, (c) THz pulse transmitted through MXene film with optical pump, (d)Transient enhancement of THz transmission following 800 nm excitation.

We have investigated the THz EMI shielding properties of $Ti_3C_2T_y$ in THz range, and find that high THz conductivity results in excellent EMI shielding properties [3,4]. We also report that excitation with optical pulses suppresses THz conductivity and increases THz transmission by as much as 3-4%, lasting for nanoseconds. This observation suggests application of $Ti_3C_2T_y$ MXene in optically switchable EMI shielding.

II. RESULTS

We have carried out THz time-domain spectroscopy and optical pump-THz probe measurements on a 25 nm-thick $Ti_3C_2T_y$ film (Fig. 1). We find that the intrinsic carrier density is high at $\sim 2 \times 10^{21}$ cm, resulting in the DC conductivity $\sigma_{DC} \approx 1250\ (\Omega.\text{cm})^{-1}$ and EMI shielding efficiency (SE) is as high as ~2.5 dB in 0.25−2.25 THz range [4]. By accounting film density and thickness, we could calculate the specific SE is at $\sim 4 \times 10^5$ dB cm^2 g^{-1}.

We also find that both 800 and 400 nm, 100 fs pulses enhance transmission of the THz pulses due to the photoinduced transient decrease in the conductivity over the entire experimental frequency range. This effect persists for nanoseconds after excitation, and its magnitude increases linearly with excitation fluence (up to 950 μJ/cm^2 and 180 μJ/cm^2 for 800nm and 400nm, respectively).

Furthermore, we find that the magnitude of this effect and its dynamics are unchanged when the temperature is decreased from 290 to 95 K, ruling out thermal effects as primary reasons for the observed behavior. Future experiments and theoretical investigations are needed to fully understand this effect, which has a whole range of potential applications in dynamically controlled THz EMI shielding and sensitive optically-gated THz detectors.

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