Photoconductive THz detection with flakes of black phosphorus

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Time-resolved photoconductive (PC) THz detection is a well-established method that allows measuring not only the intensity, but also the phase of THz radiation. The conductivity of a semiconductor material is temporarily increased by an ultrashort probe pulse; the impinging electric field of a THz pulse drives the photoexcited carriers, therewith generating a measurable current that depends on the time delay between the THz pulse and the probe pulse [1]. Two-dimensional black phosphorus (bP) is an attractive material for PC THz emission and detection as it provides an adjustable bandgap of 0.3 eV to 2 eV in combination with a high carrier mobility [2]. In this study, we present PC THz detection based on bP flakes with a thickness of about 30 nm.

The bP is exfoliated from a bulk bP crystal onto SiO_2 on Si. A logarithmic periodic antenna (100 nm Au on 10 nm Cr) is patterned by photolithography to concentrate the THz field to the subwavelength flake (~ 10 µm) and provide electrical contacts. To prevent degradation of the bP flake in the ambient evironment, the whole device is capped by 100 nm of Al_2O_3 [4]. The device performance is tested in a standard THz time-domain spectroscopy setup. A large area PC THz emitter, based on semiinsulating GaAs [3], is pumped by fs laser pulses at a wavelength of 800 nm. The THz radiation is collimated and refocused to the device by a pair of off-axis parabolic mirrors; a time-delayed portion of the 800 nm beam is used as probe pulse to temporally gate the conductivity of the bP flake. The resulting photocurrent as a function of the time delay is plotted in Fig. 1. We achieved a signal-to-noise ratio of about 500, proving the potential of bP for PC THz applications. The low band gap of the bP flake allows PC THz detection at longer probe wavelengths, which is part of our ongoing research.

References

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Figures

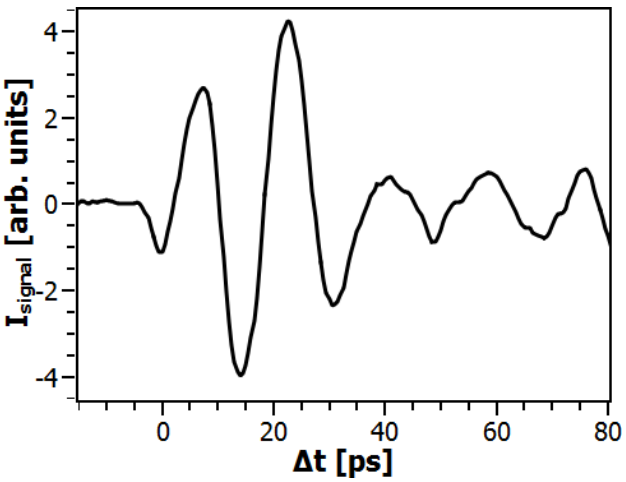

Figure 1: THz transient measured with an antenna coupled black phosphorus flake at a probe wavelength of 800 nm.