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Non-linear terahertz detection with graphene field-effect transistor terahertz detectors

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Graphene, a single-layer allotrope of carbon, holds significant potential in terahertz (THz) electronics. By encapsulation between hexagonal boron nitride flakes, graphene field-effect transistors (GFETs) demonstrate room temperature electron mobility up to 60,000 $cm^2/(Vs)$ [1]. Furthermore, peculiarities of intraband electron dynamics in graphene result in strong nonlinearity in the infrared and optical frequency ranges [2]. Recently, up to the 7th harmonic generation has been reported by transmitting high-intensity THz radiation through monolayer graphene [3]. This study aims to demonstrate similar nonlinearity in GFETs, as an electronic device.

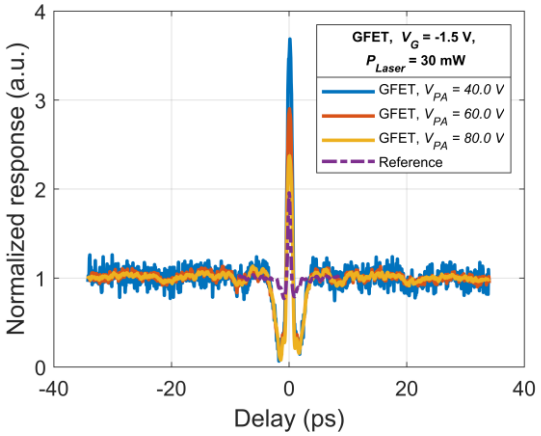

Fig. 1. Measured interferogram of GFET detector and Golay cell responses to incident THz pulse. The power of the source is varied by selecting the laser power P_{Laser} and a voltage V_{PA} applied to the GaAs photo-antenna.

GFET structures were made from monolayer CVD graphene with Au bow-tie antennae (240 µm diameter) grown on top. A 12 mm hyper-hemispherical Si lens was used to focus the radiation onto the antenna. More information about the GFET detectors can be found in [4].

During the experiment, the detector was illuminated with femtosecond THz pulses generated by a GaAs photo-antenna excited by a red (790 nm, 100 fs) laser. A Michelson interferometer was used to measure the pulse autocorrelation. Reference measurements were taken with a Golay cell. The nonlinearities of GFETs response were investigated by varying the gate voltage and the THz pulse power.

The exemplary experimental autocorrelation traces are shown in Fig. 1. The reference case with a linear power detector shows a ratio of 2 between the incoherent and coherent (near time-delay zero) power summation. Using the GFET THz detector this ratio can reach 3.7 indicating that the response at these excitation conditions is closely proportional to power squared. This phenomenon could be used for real-time THz spectroscopy, creating GFET THz sources and nonlinear devices like high-frequency mixers.

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