Thermoelectric photodetector using monolayer graphene and metal electrodes of different working functions

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We report a thermoelectric photodetector using monolayer graphene and metal electrodes with different working functions for infrared and terahertz (THz) sensing applications. The sample structure is shown in Fig. 1(a). Finger-crossing like metal electrodes were fabricated on semi-insulating GaAs substrate with two types of metals, i.e., Au and Al, which give different working functions at 5.1 eV, and 4.18 eV, respectively[1]. The width of Au and Al electrodes is 4 μm with gaps of 4 μm between two neighbored electrodes. Then, a monolayer of CVD-grown graphene is transferred to the surface of the metal electrodes as a thermoelectric layer[2]. A microscope image of a fabricated sample is shown in Fig.1(b).

When the electrons in the graphene layer are excited photothermally, the hot electrons are driven by electrical field formed by the two different metals, and give a net current from Au to Al electrodes. We have confirmed the optical response by using a 1.5 μm infrared femtosecond laser, which has a much smaller photon-energy than the bandgap of the GaAs substrate, so that no photoexcitation occurs in the substrate. When the incident light to the sample is chopped, we observed changes in the net current through the Au-Al electrodes, as shown in Fig. 1(c). The observed signal rising time (~100 μs) is mainly limited by the optical chopper itself, and the thermal response time is expected to be ps~ns level[2]. The fast response would be very useful in fast infrared and THz imaging applications.

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Ref. [1] Toshiyuki Sameshima, et al., JJAP,49,110205 (2010). [2] Xinghan Cai, et al., Nat. Nanotech., 9, 814–819(2014)

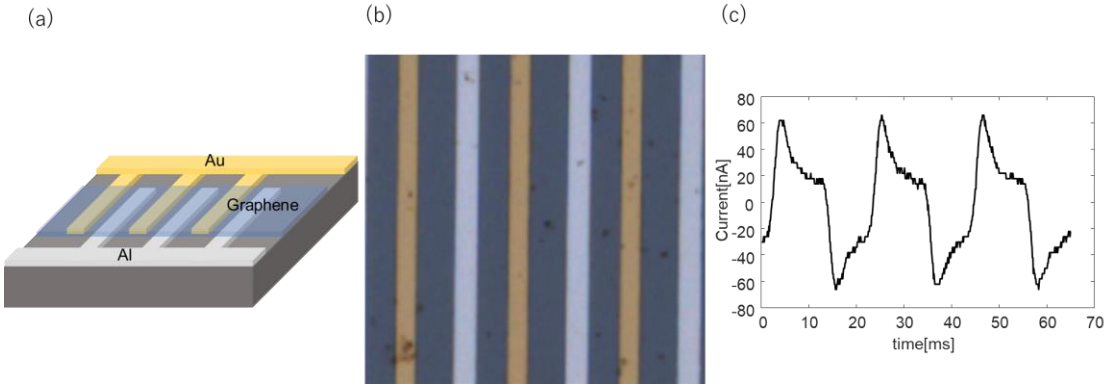

Fig.1 (a) Schematic sample structure of the thermoelectric photodetector. (b) A microscope image of a fabricated sample. (c) Changes in the net current through the Au-Al electrodes when incident light was switch on and off.