Thermoelectric photodetector using CVD graphene and asymmetric-metal electrodes

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Graphene is very attractive for the development of high-speed photodetector owing to its excellent electrical and optical properties. Among all the successful demonstrations of graphene photodetectors, the photodetector with asymmetric metal contacts have attracted lots of research interests because of the advantages of high sensitivity and low dark current. The previous works have used mono-layer graphene to reduce the electron-phonon interaction and maximize the electron mean free path. However, a monolayer graphene only has very small optical absorption, which limits the further improvement of optical sensitivity of graphene photodetectors.

We report a thermoelectric photodetector based on a suspended multi-layer CVD-grown graphene layer and asymmetric metal electrodes of different working functions. The sample structure is shown in Fig. 1(a). Multilayer (6~8 layers) CVD grown graphene was transferred to a silicon(Si)/SiO2 substrate, and patterned to small dashes (length: 30 µm, width: 6-10 µm,) by O2 plasma etching. Electrodes of two types of metals (Au and Al) were deposited to contract the graphene dashes, which have different working functions at 5.1 eV, and 4.18 eV, respectively[1,2]. Vapor HF etching was performed to remove the SiO_2 under the graphene to form the suspended beam structure. A laser microscope image of a fabricated sample is shown in Fig.1(b).

To estimate the optical responsivity of the photodetector, we illuminate the photodetector with a 400 nm pulse laser to heat up the graphene layer. The suspended graphene layer becomes hot and the graphene layer beneath the metal electrodes is cool. The hot electrodes are driven by the field gradient formed by the asymmetric metal electrodes, and gives an open-circuit voltage in the Au-Al electrodes. Figure 1(c) shows the output voltage as a function of the illumination light power.　As seen, at weak illumination (<2 mW), the responsivity is about ~90 V/W. However, when the illumination power becomes large, the output voltage saturates at about 200 mV. The reported graphene photodetector may be useful for the development of fast and sensitive uncooled terahertz detector.

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Ref. [1] Xinghan Cai, et al., Nat. Nanotech., 9, 814–819(2014). [2] Tae Jin Yoo, et al., ACS Photonics, 365–370(2017)

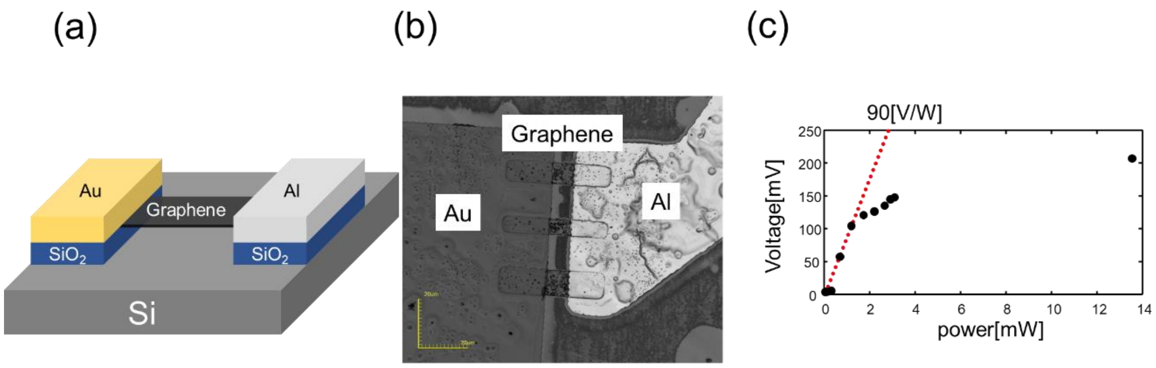

Fig.1 (a) Schematic sample structure of the thermoelectric photodetector. (b) A microscope image of a fabricated sample. (c) The output voltage as a function of the illumination light power.