Photothermoelectric Terahertz Detection with p–n Junction Nanoporous Graphene

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Room-temperature terahertz (THz) sensors are strongly demanded in diverse fields, such as security, agriculture, astronomy, and materials science. The outstanding optical properties of graphene are highly promising for the realization of sensitive THz detection. Despite strong advantages, graphene THz detectors have plenty of room for performance enhancement in terms of absorption rate and gain of the photoresponse. We here report the fabrication of three-dimensional (3D) nanoporous graphene (Fig. 1) that retains Dirac cone of mono-layer graphene, and demonstrate photothermoelectric THz detection under room temperature.

In contrast to mono-layer graphene, the light absorption rate of nanoporous graphene exceeds 90% in a broadband spectrum range from THz to ultraviolet band, due to its unique 3D structure [1]. To efficiently gain the photothermoelectric response, we developed a p-n junction device by dropping a 15-crown-5-ether and sodium hydroxide (NaOH) mixture [2], which changes carriers from p-type to n-type. Figure 2(a) shows that the nanoporous graphene with averaged porous size around 100-300 nm has a large Seebeck coefficient (p-type), and that the crown ether and NaOH mixture efficiently converts the sample into n-type [2]. Through such a chemical doping method, we successfully created a p-n junction 3D graphene device, as depicted in Fig. 2 (b), and then measured the THz photoresponse of this detector (Fig. 3 (a)). Figure 3(b) presents *I-V* curves with/without 29-THz irradiation, indicating a clear shift due to the photothermoelectric effect. In this talk, we will discuss topological effects originating from the 3D curved surface geometry characteristic to this material.

References

[1] Y. Ito, et al, Adv. Mater., 29 (2015) 4302-4307.
[2] Y. Nonoguchi, et al, Adv. Funct. Mater., 26 (2016) 3021-3028.

Figures

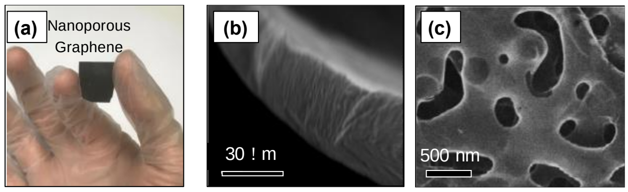

Figure 1: (a) Optical Image of nanoporous graphene. (b) Cross-sectional and (c) close-up images, obtained by a scanning electron microscope.

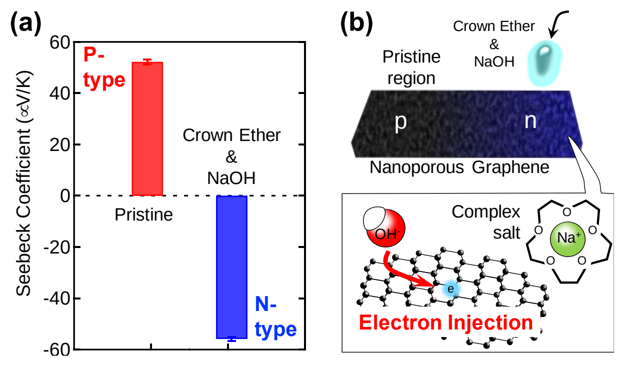

Figure 2: (a) Seebeck coefficient of the p-(pristine) and n-type (chemically-doped) nanoporous graphene. (b) Schematic of the creation of the p-n junction.

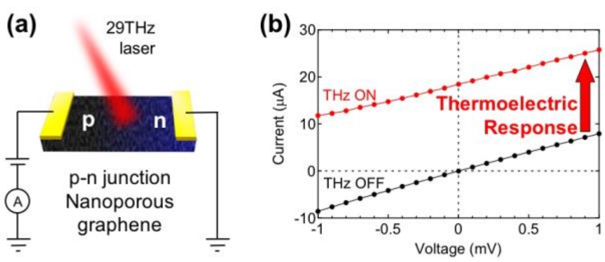

Figure 3: (a) THz measurement setup. (b) *I-V* characteristics with/without the 29-THz waves.