Near-infrared photodetection using graphene sheets coupled with metallic nanoantennas

Sasipa Kanchanaluk, Mongkol Sapankaew, and Yodchay Jompol*

Department of Physics, Faculty of Science, Mahidol University, Bangkok, Thailand

*Corresponding Author: yodchay.jom@mahidol.ac.th

Abstract: Owing to its strong light-matter interaction, graphene has been considered as the thinnest nanomaterial that could pave the next generation of optoelectronic and photonic applications. Here, we present an experimental consideration of using plasmonic properties of graphene sheets coupled with metallic nanoantennas towards the fabrication of a THz detector. The detection of the photocurrent in the graphene sheets was studied as a function of the number and period of the antennas that were lithographically defined on top of the encapsulated graphene by atomic-layer deposition of aluminum oxide (Al_2O_3). We found negative photocurrent in all investigated samples that could be described due to the scattering of excess charge carriers under the excitation of near-infrared (NIR) laser (λ=975nm) at 435 mW power. The negative photocurrent was obtained by ~ 3% for a given period of the antennas but increased significantly up to 77% above that without the use of antennas. This finding indicates the plasmonic enhancement in graphene by coupling with nanoscale conducting objects. Such a change in the photocurrent at a given bias implies that the graphene sheet resistance is less significant than the optical sheet resistance where the quantum resistance of graphene is set to $h/4e^2 \sim 6.5\ k\Omega$, where h Planck's constant and e electric charge. The device photoresponsivity up to ~ 2 mA/W was achieved at a maximum illumination power with a few-second time response. This slow detection of our graphene devices implied a long diffusion length within the device channel of the high purity graphene sheet. Further improvement to gain the device's sensitivity could be achieved by optimizing the device dimensions and implementing a large number of metallic nanoantennas for high-efficiency plasmonic coupling.

Keywords: Graphene plasmonics, Near-infrared photodetection, Nanoantenars, Terahertz (THz) detector