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Plasmonics for Mid-Infrared Light Concentration in Continuous Graphene

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Extended Abstract

Low-dimension materials such as thin-film semiconductors, MoS_2, carbon nanotubes, and nano-wires are attractive for a wide range of electronics, photonics, and optoelectronics applications [1]. These materials have been widely studied in the area of plasmonics and nanophotonics since their mono-layer thickness provides an advantage in many applications such as flexible electronics, high-performance electronics, and detector applications. Graphene, 2D material with atomic thickness, is a promising candidate material for ultra-broadband photodetectors, as its absorption spectrum covers the entire ultraviolet to far-infrared range. However, graphene has an optical properties that absorbing 2.3% of the incident light in average [2]. In many recent research, graphene has combined with plasmonic structures to overcome this drawback. Enhanced transmission or absorption of light has always been of interest in plasmonics and photonics. Extraordinary optical transmission (EOT) through sub-wavelength apertures or nanoparticles have been studied thoroughly. By using gratings, incident light can couple strongly to plasmons propagating through periodically spaced slits in a metal film, resulting in a strong, resonant absorption [3]. With similar motivations, much of the work has been shown electromagnetic transmission through a metal film with the mediation of surface plasmons. Here we report a grating-based surface plasmons to enhance mid-infrared (mid-IR) absorption of continuous graphene film.

For the enhanced light absorption layer, we use finite-difference time-domain (FDTD) simulation tool to simulate the optical response of the graphene/gold plasmonic structure. FDTD method is a powerful method to solve the Maxwell's equations in a nanostructure with arbitrary and symmetrical structures by using YEE-algorithm [4]. In order to design a more accurate structure, various parameters such as height, period, and fill factor were simulated. Based on the simulated data, Au nanoslit arrays is fabricated by UV-lithography technique. The substrate can be structured in one-step directly obtaining a periodic array on large areas in a few seconds. Immediately after the fabrication graphene/metal hybrid structure, we have acquired the transmittance/reflectance/absorbance spectrum by using Fourier-transform infrared spectroscopy (FT-IR). Through absorbancce spectrum, it was confirmed that the absorption of graphene has increased for about 2 times at around 9 μm by nanoslit array. The hybrid structure of universe optical absorption of graphene and strong surface plasmonic resonance (SPR) of Au slits leads to exciting prospects for mid-IR light concentration.

References

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