Nonlinear Optical response of graphene under CW He-Ne laser excitation

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Abstract

Rapid advances in the field of nanoscience and nanotechnology have enhanced the new opportunities for nonlinear optics. Large number of nanomaterials possessing noticeable nonlinear optical (NLO) properties has been investigated for optoelectronic and photonic device applications. Among the wide variety of materials investigated for nonlinear optical applications, graphene has drawn considerable interest due to its good optical transparency, robustness and environmental stability. Graphene is an one-atom-thick two-dimensional (2D) layers of carbon with a hexagonal packed structure [1]. Graphene being a carbon-based material offers flexibility in tailoring the NLO properties by modifying the chemical structure. In this article, we present nonlinear optical and optical limiting properties of graphene investigated using single beam Z-scan technique [2]. The experimental set up used is similar to that reported in the literature [3]. Experiments were performed by using Thor labs HRP350-EC-1 continuous wave (CW) He-Ne laser at 633nm wavelength as an excitation source and the resultant output power through the samples were recorded using a photo-detector fed to Thor labs PM320E dual channel optical power and energy meter. The laser beam with input power 21.9 mW was focused to a spot size of 36.78 µm and the Rayleigh length Z_R of 6.71 mm using a 5 cm focal length lens. The thin sample approximation is valid, since the sample was taken in a quartz cuvette having an optical path of 1mm. The nonlinear absorption co-efficient β_{eff} , was measured using the Z-scan technique and found to be 1.21 x 10^{-2} cm/W. Two photon absorption (TPA) found to be the nonlinear absorption process in graphene. The UV-Vis absorption spectrum of the graphene shown in Figure1 reveals that there is strong absorption in the region 200nm to 350 nm, followed by a monotonously decrease in absorption towards long wavelength region. Optical limiting materials with low thresholds can be used for protection of eyes and sensitive optical devices from laser-induced damage. In this context, optical power limiting studies were carried out by placing the sample at the focal plane of the lens in the z-scan experiment. The input power of the laser beam was varied by using neutral density filter and the change in the output power was recorded using a photo-detector fed to power meter. The graphene exhibits a good optical power limiting behaviour under CW laser illumination at 633nm wavelength. Figure2 shows the optical power limiting behaviour of the graphene as a function of incident power varying from 0.2 mW to 20 mW. The optical limiting threshold for the graphene was found be ~4.5mW and the optical clamping occurs at ~3.4mW. The good optical power handling capability of laser beam at the 633nm experimental wavelength indicates the possible photonics device application of graphene such as all-optical power limiting.

References

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Figures

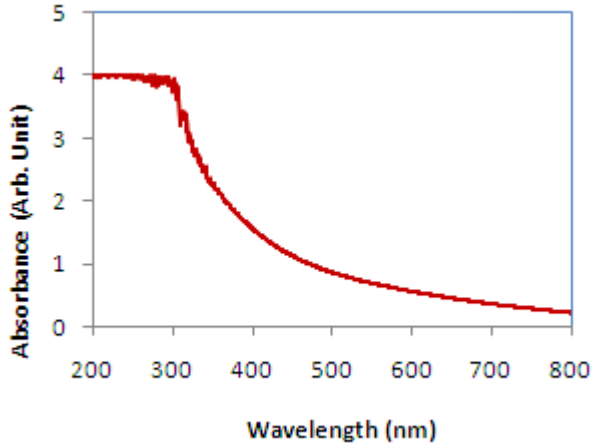

Figure1. UV-Visible absorbance spectra of Graphene.

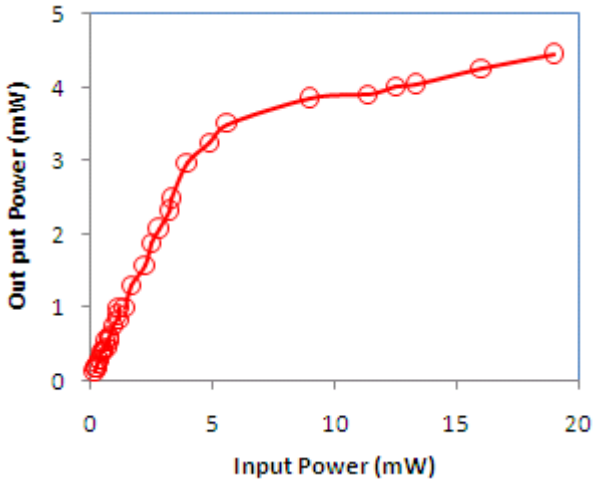

Figure2. Optical power limiting response of graphene under continuous wave 633nm irradiation.