Electrical and optical properties of graphene: Possible candidate for optical applications

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Abstract

The recent discovery of graphene has attracted a rapid burst of research attention in this material [1]. It is well known that graphene is a 2-dimensional, crystalline allotrope of carbon. In graphene, carbon atoms are densely packed in a hexagonal pattern and can be described as a one-atom thick layer of graphite. The unique topology of hexagonal arrangement of carbon atoms provides an extraordinary energy dispersion relation near the Fermi energy in graphene. It has attracted lot of attention in the recent times essentially due to the fact that one can tailor the structure in order to change its fundamental properties. Graphene is perhaps the only form of carbon (and generally all solid materials) in which each single atom is in contact for chemical reaction from two sides which is essentially due to the 2D structure.

In the present work we have investigated electrical and optical properties of graphene. We have prepared graphene by the following process. Commercially available graphite (Aldrich 99%) was converted into graphene oxide using modified Hummers method. Graphene oxide thus obtained was reduced to graphene oxide (rGO). This was finally converted into graphene using hydrazine hydrate. The electrical resistivity $\rho(T)$ was measured in the temperature (T) range 10-300K using standard four-probe method in a closed cycle refrigerator (CCR). Lakeshore temperature controller-Model 325 was used to measure and control the temperature of the sample. Keithley current source (Model 6221) was used to keep constant current through the current leads, and the voltage across the voltage leads was measured by Keithley nano-voltmeter (model 2182A). The temperature dependence of resistivity shows that temperature does not have appreciable effect on resistivity. Similar results are reported in literature [2]. This suppressed temperature dependence additionally suggests that the dominant scattering mechanism likely stems from static impurities.

The optical limiting properties of graphene investigated using single beam Z-scan technique [3]. Experiments were performed by using a continuous wave (CW) He-Ne laser at 633nm wavelength. Figure 1 depicts the optical power limiting behaviour of the graphene as a function of incident power

varying from 0.2 mW to 25 mW. The graphene exhibits a good optical power limiting behaviour under CW laser illumination at 633nm wavelength. The optical limiting threshold for the graphene was found ~10mW. The present results suggest that graphene can be a potential candidate for optical limiters.

References

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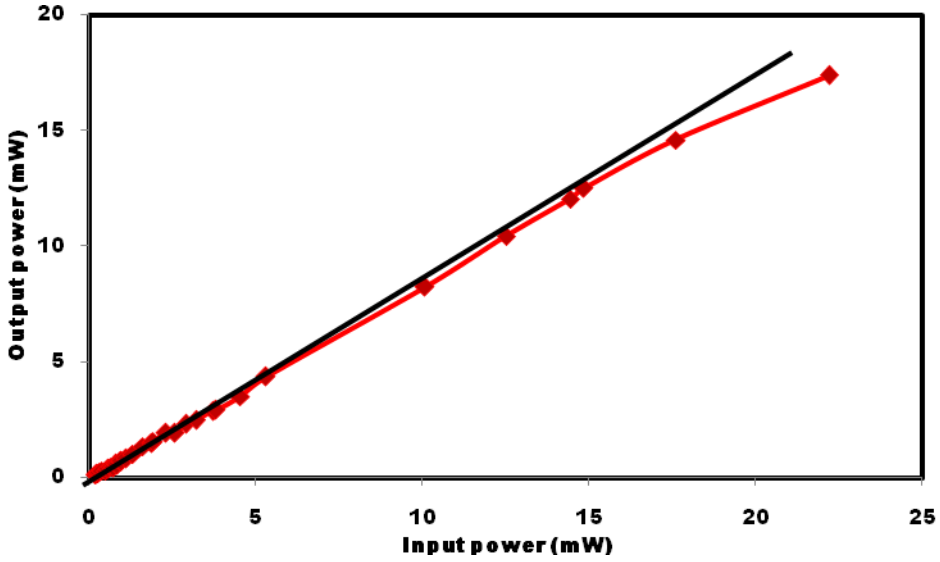

Figure 1. Optical power limiting response of graphene under continuous wave 633nm irradiation.