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Enhancement of photoluminescence from graphene oxide due to surface plasmons

Sanjay Karna[1], Rakesh Shah[1], Ryoko Shimada[2], Zhiming Wang[3], Arup Neogi[1]

[1] University of North Texas, [2] Japan Women's University, [3]UESTC, China
E-mail: arup@unt.edu

1. Introduction

The presence of long range surface plasmons near an emitter can enhance the radiative recombination rate in an emitter [1] resulting in the enhancement in photoluminescence emission from semiconductor light emitters [2]. Recently there has been active interest in the generation of light from graphene based materials. Graphene oxide in particular can be tailored to emit light over a wide range of visible to the near-infrared wavelength by controlling the reduction of graphene in the presence of oxygen and by controlling the ratio of the sp^2 and sp^3 cluster [3]. In the present work we present the broadband emission from graphene oxide (GO) and reduced graphene oxide (rGO). We demonstrate that the photoluminescence from graphene oxide can be enhanced due to the coupling of the emitted photons with resonant surface plasmons.

2. Material and Methods

Material Synthesis:

The GO was prepared using modified Hummer's method [4]. Partial reduction of GO (rGO) was obtained chemically using hydrazine monohydrate. The rGO sample was purified by repeated filtration and washing with ethanol. The samples for optical property measurement were prepared by drop casting of GO dispersion on quartz substrate. This produces layered structure of GO and rGO thin film with normal orthogonal to the substrate.

Structural Characterization:

The structure was characterized using transmission electron microscopy and corroborated using Raman Spectroscopy. Multilayer GO and rGO films were formed on the substrate with layer thickness varying from 235-200nm.

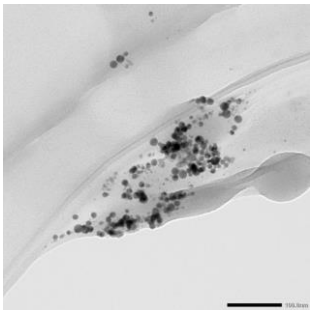

Fig.1. Transmission electron micrograph of graphene oxide with light emission characteristics. (Scale bar 100nm)

Optical Characterization:

The structural properties were further investigated using Raman spectroscopy which showed the presence of sp^2 and sp^3 clusters in the graphene oxide composite. It has been observed that the crystallite size of sp^2 hybridized domains for GO is ~ 21 nm and the size is reduced to ~17 nm for the case of rGO.

The photoluminescence (PL) emission study of both graphene oxide (GO) and partially-reduced graphene oxide (rGO) have been investigated. It has been observed that the GO has broadband emission from green to near infrared range and upon reduction rGO shows blue PL emission. The broadband PL emission is due to the recombination of electron-hole pair in sp^2 domain embedded within sp^3 matrix. The broadband PL emission also suggests the existence of various sizes of sp^2 domain within the same matrix.

2. Surface plasmon induced light enhancement

Further, PL emission from GO in the presence of Au metal thin film has been investigated. It has been observed that the entire broadband emission from GO in the green to near infrared wavelength region is enhanced significantly at room temperature (Fig.2). The Au-GO interface exhibits surface plasmon resonance in the visible wavelength region and is responsible for over 10 fold enhancement in the photoluminescence at ~2.36 eV.

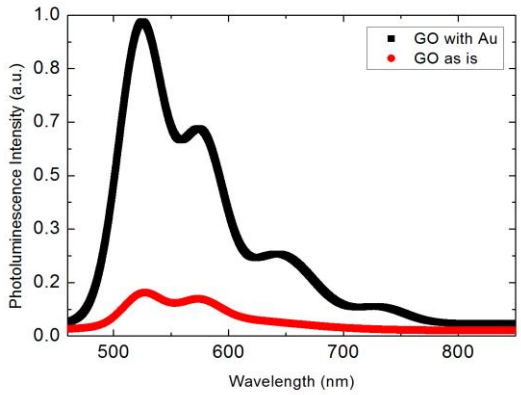

Figure 2. Surface plasmon induced enhancement of photoluminescence due to Au metal film on graphene oxide

These properties make the material quite suitable for fabrication of new generation photonic devices.

References

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