Enhancement of photoluminescence from graphene oxide due to surface plasmons

Sanjay Karna¹, Rakesh Shah¹, Ryoko Shimada², Zhiming Wang³, Arup Neogi¹

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 sp² and sp³ 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.

Optical Characterization:
The structural properties were further investigated using Raman spectroscopy which showed the presence of sp² and sp³ clusters in the graphene oxide composite. It has been observed that the crystallite size of sp² 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 sp² domain embedded within sp³ matrix. The broadband PL emission also suggests the existence of various sizes of sp² 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.

References