Enabling Photodetection in Graphene Using Quantum Dots

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ENLACE 2022 Summer Research Experience

Background

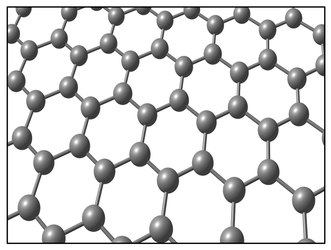

Image 1. *Graphene 3D molecular structure*

- Graphene (Gr) has excellent conductivity and charge mobility, it presents an enticing application for **optoelectronics**[1,2]. Gr is very thin, flexible and can be fabricated on a large scale[2].

- Quantum dots (QD's) are nanocrystalline materials, they have extraordinarily **strong light absorption** and size-tunable emission[1,3].

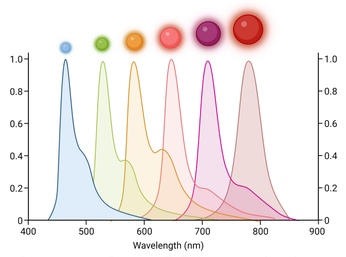

Image 2. *QD's emission scheme*

- QD's present fluorescence, due to the band gap between the valence and the conduction electron bands, and absorption of a photon higher in energy[3].

As a **2D nanomaterial**, the one atom thickness of graphene, limits its radiation absorbance, by combining Gr/QDs, quantum dots **generate photocarriers** that are then transferred to graphene for **efficient charge transport** and **photocurrent generation**[4].

We aim to develop a graphene-based integrated photosensor by coupling it with quantum dots of lead sulfide.

Methods

The samples were made in a 2-step process:

1. Graphene wet transfer on SiO2/Si with Au/Cr electrodes.
2. Spin-coating of PbS quantum dots.

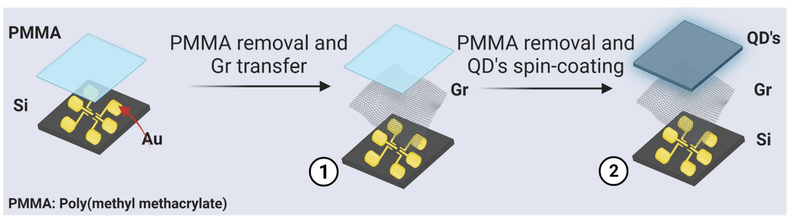

Image 3. *hybrid Gr/QD's system preparation scheme*

- Measurements were taken on a source meter.
- Responsiveness of Gr/QD's system was evaluated on a 532 nm laser.
- Images were obtained on a compound microscope at 5x.

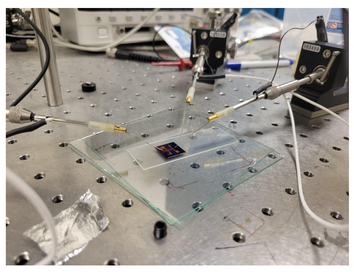

Image 4. *Electrode set up*

Low Photoresponsivity of Gr

The presence or absence of light seems to have no effect on the conductance of graphene.

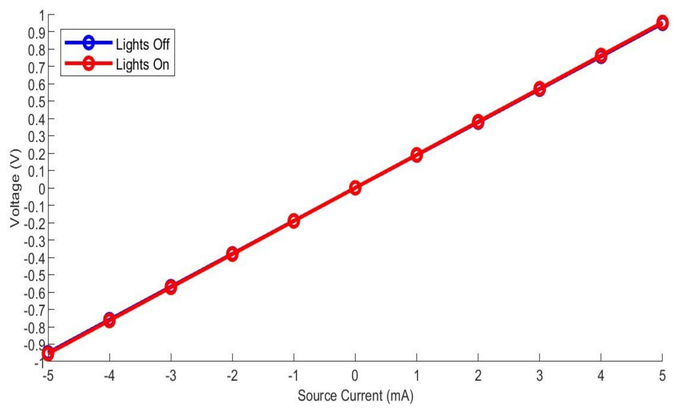

Figure 1. I vs. V using Graphene Sample

There is no apparent difference in the voltage readings between the graphene sample with the lights on and the sample with the lights off.

QD's Enable Light Absorption

The current reading is lower in the case with the lights off which indicates a lower resistance and thus higher conductance.

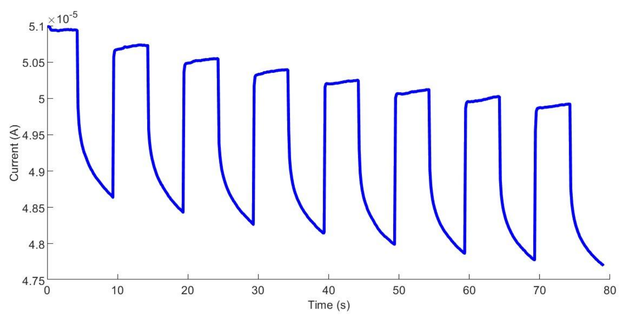

Figure 2. I vs t using Gr/QD Sample

There is difference in the current readings between the graphene sample with quantum dots with lights on vs lights off.

Photoresponse and Conductance

A higher illumination value results in a lower resistance and thus higher conductance.

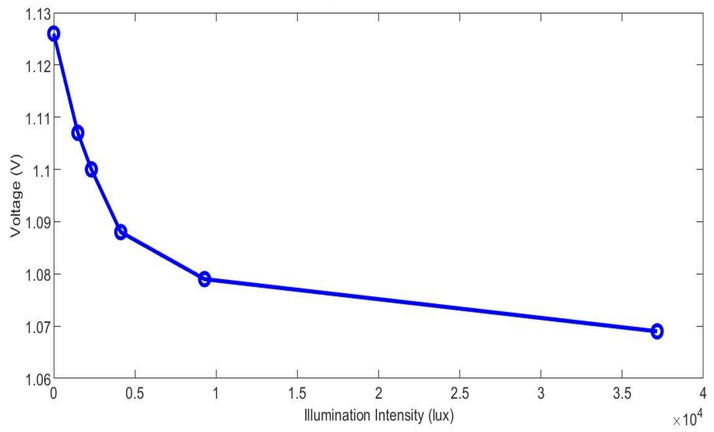

Figure 3. Illumination Intensity vs. V using Gr/QD Sample at 5 mA.

Therefore by applying Ohm's law it can be determined that It presents an inverse relationship between measured voltage and illumination.

Sample Results

The surface of Si changes, graphene shows creases and the addition of Quantum dots gives a blue tint to the surface.

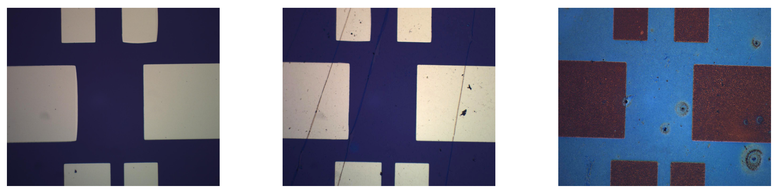

Image 5.a,b,c*. From left to right: clean chip, chip with Gr, SiO2/Si chip with GR and spincoated QD's.*

Applications

Hybrid Gr/QD photodetectors allow for applications predominantly within the **electronic and biological fields.**

Their applicability within these fields stems from the drastic increase in photoresponsivity resulting from the combination of the two nanomaterials.

This hybrid photodetector has applications in [5]:

- Communications and remote sensing: Terahertz technology
- Environmental monitoring

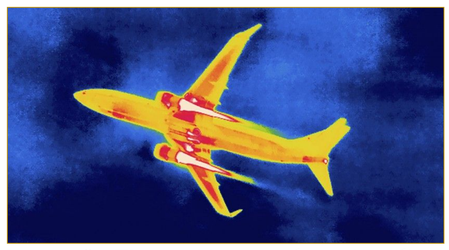

Image 6. *Thermal image of an aircraft*

- Surveillance: Infrared imaging systems with enhanced capabilities

Conclusions

When Graphene and Quantum Dots are put together, they exhibit a photo sensing capacity

Additionally, proper design parameters regarding the QD size and film thickness allows for a high response and tunable spectrum of the hybrid photodetector [4].

References

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This project would not have been possible without the support of the ENLACE program, Dr. Olivia Graeve, Dr. Oscar Vazquez-Mena and PhD student Ju Ying Shang.

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