Electric field quenching of graphene oxide photoluminescence

Bong Han Lee, Alina Valimukhametova, Conor Ryan, Thomas Paz, Fabian Grote, and Anton Naumov

Department of Physics and Astronomy

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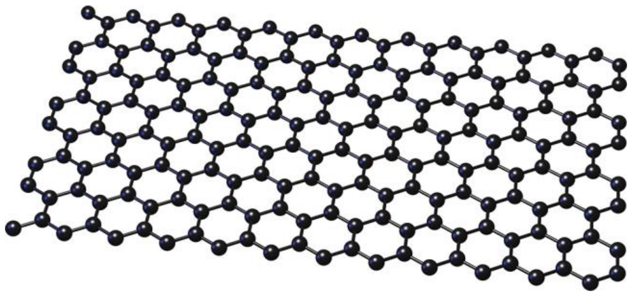
Introductory

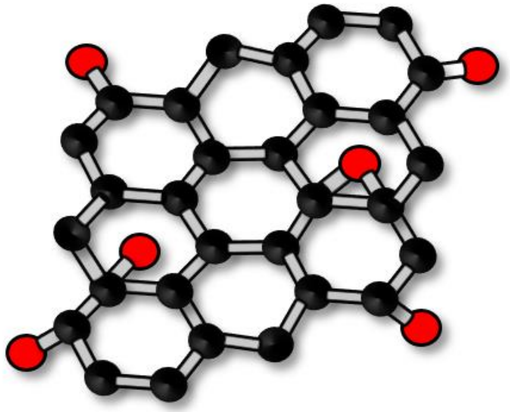
Graphene:



- Insolubility in water
- Lack of optical bandgap
- Does not fluoresce

Graphene oxide:

Is the most widely utilized derivative of graphene



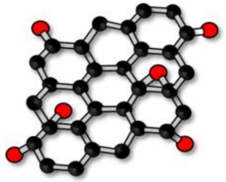
- Solubility in water due to it contains oxygen functional groups on its surface
- These groups localize regions of sp^2 carbon resulting in a band gap.
- This quantum confinement effect yields GO's fluorescence.

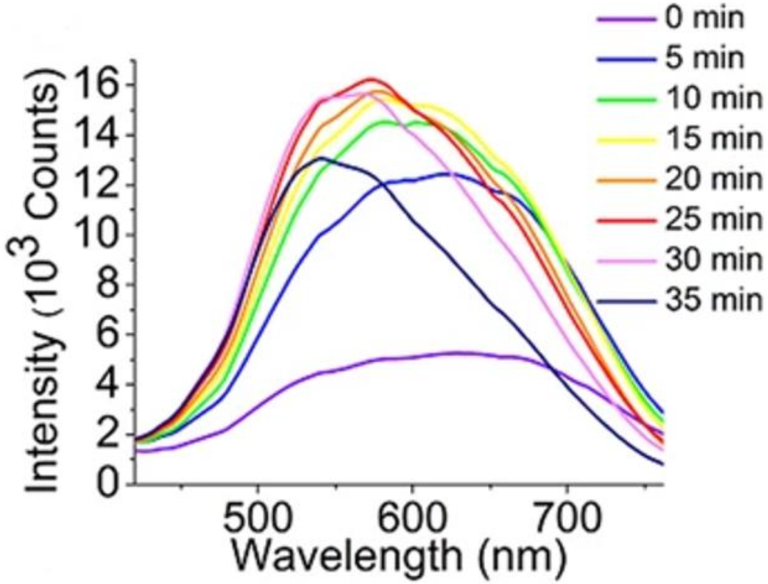
How can we control fluorescence of GO?

- **Chemical manipulations of structure**

Changing the degree of oxidation

e.g. ozone treatment



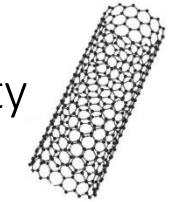


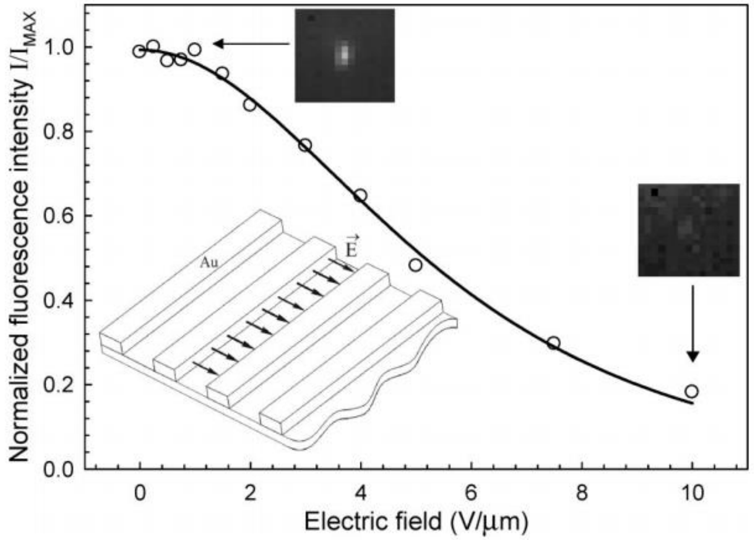
Hasan M T et al. Optical band gap alteration of graphene oxide via ozone treatment Sci. Rep. **2017** 7 6411

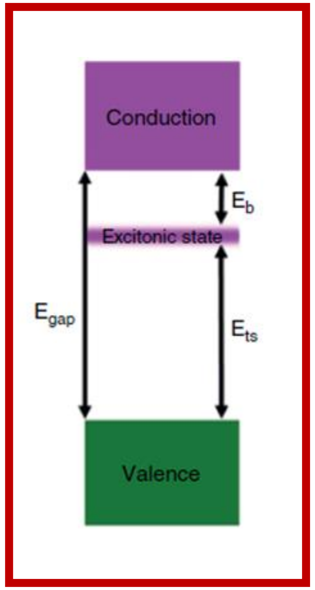
- Physical method

Applying an electric field

e.g. reversible decreases in emission intensity of single-walled carbon nanotubes while applying the electric field



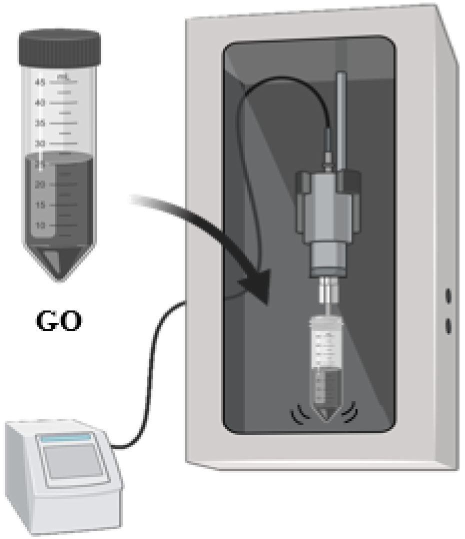




Anton V. Naumov et al. Electric Field Quenching of Carbon Nanotube Photoluminescence, Nano Lett. **2008,** 8, 5, 1527–1531

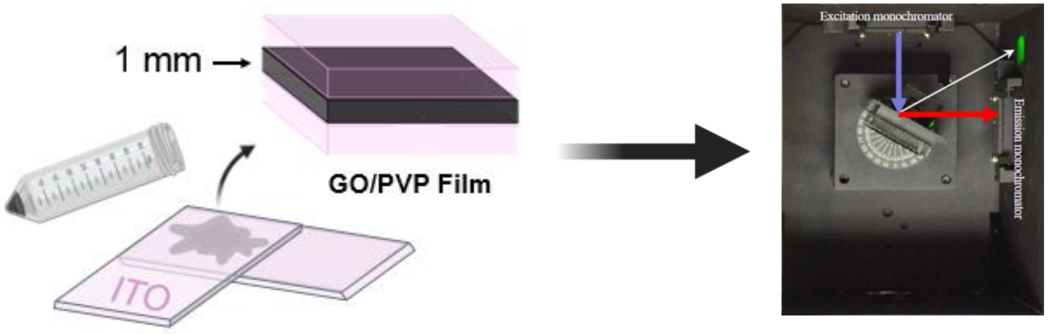
Materials and Methods

1 Tip Sonication



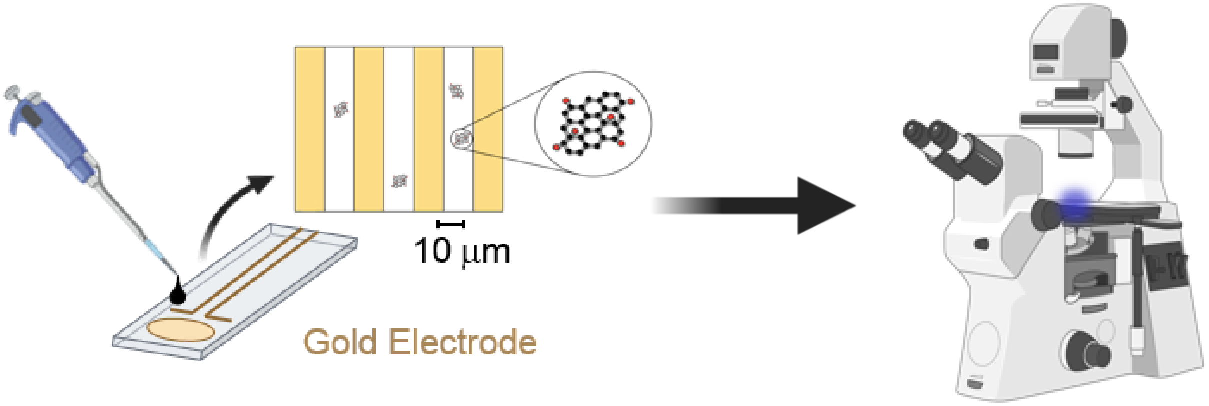
- GO is in the µm size range.
- Tip sonication was used to disperse and reduce agglomerated GO.

2 Bulk GO Sample Fluorescence Spectroscopy



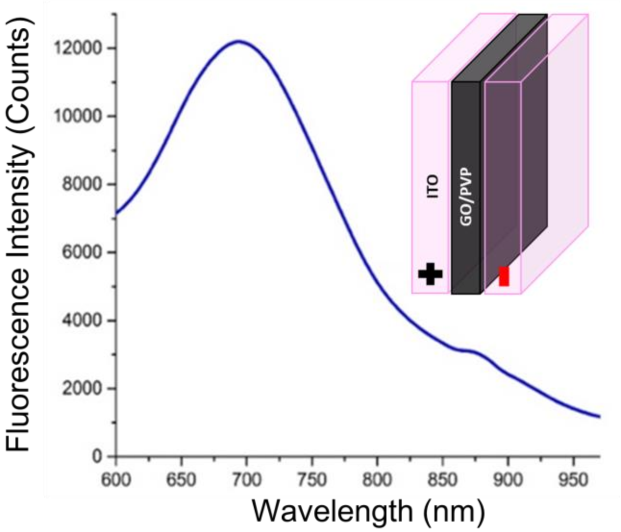
0 - 1.6 V/µm

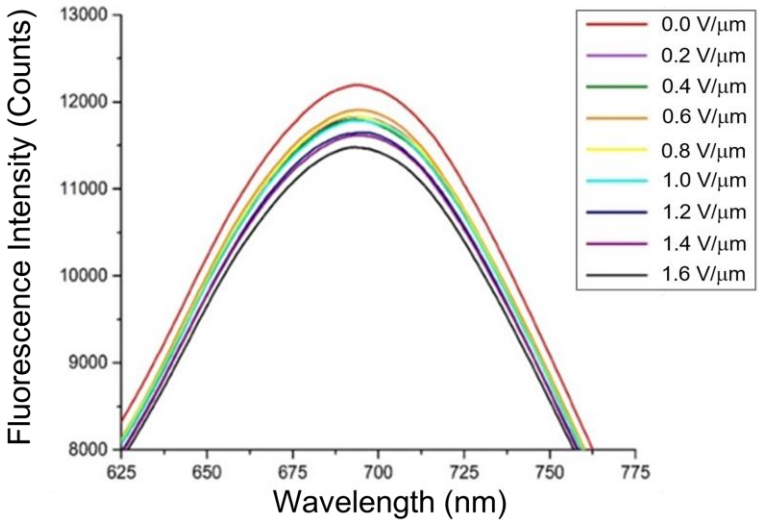
3 Single Flake GO Fluorescence Microscopy

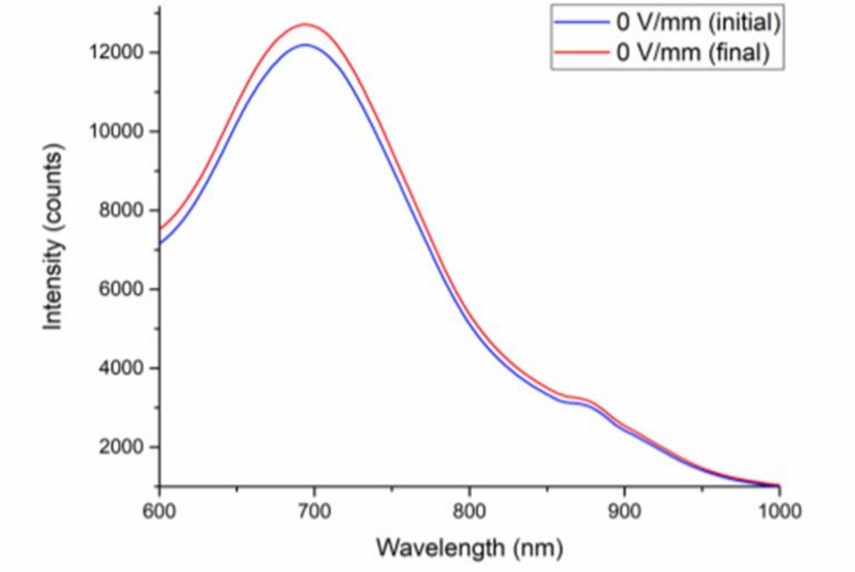


Results: Effect of Applied Electric Field onto GO/PVP film

(Ex. 440 nm)

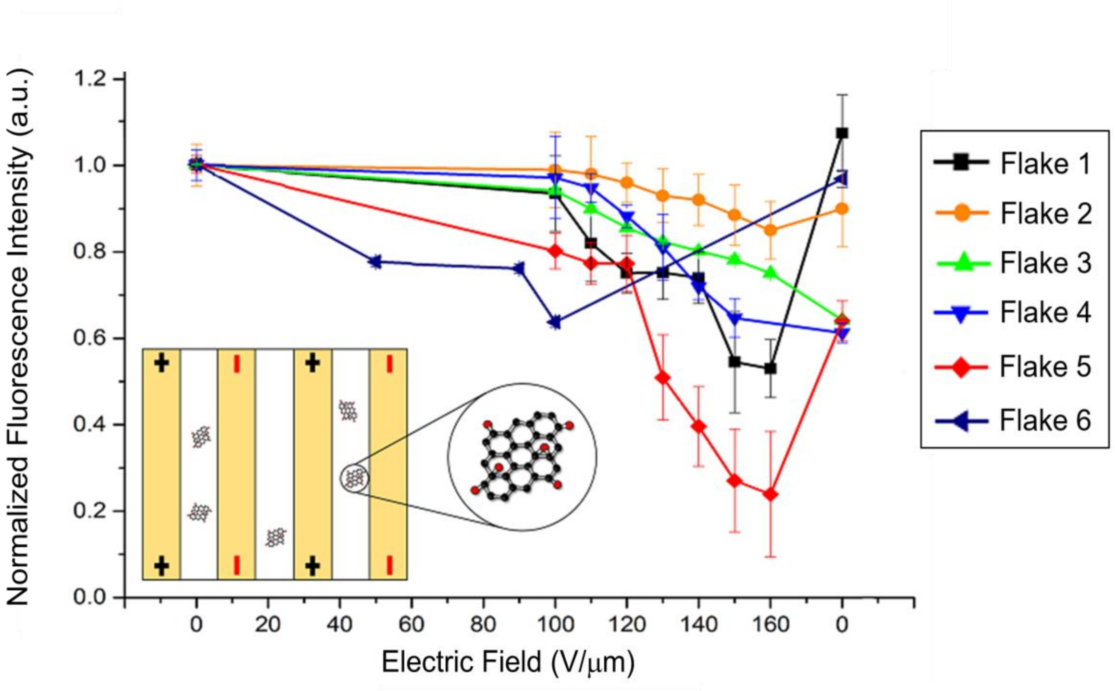


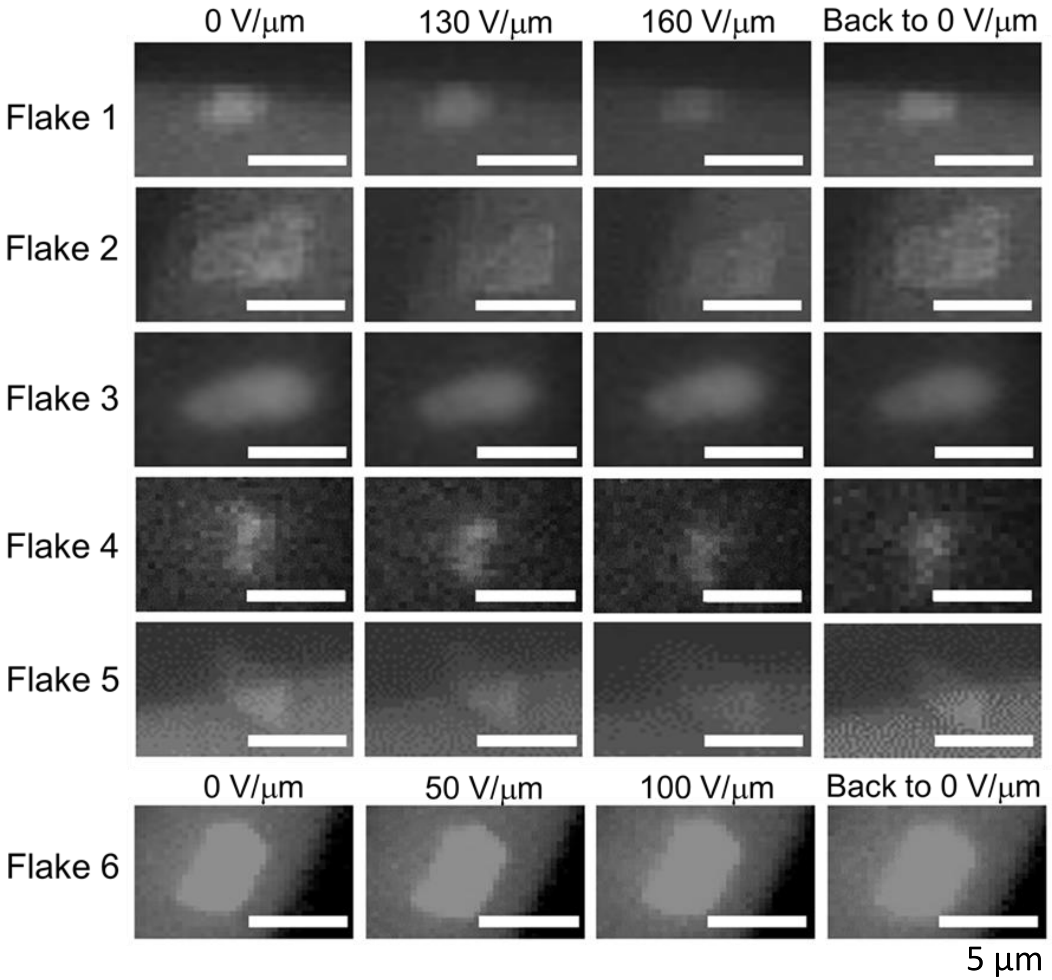




- GO/PVP film is subject to the fields of 0 - 1.6 V/μm incremented in 0.2 V/μm steps
- Fluorescence intensity gradually decreases by up to 6 % at the maximum field strength, and shows a return.

Effect of Applied Electric Field onto <u>single flake of GO</u>



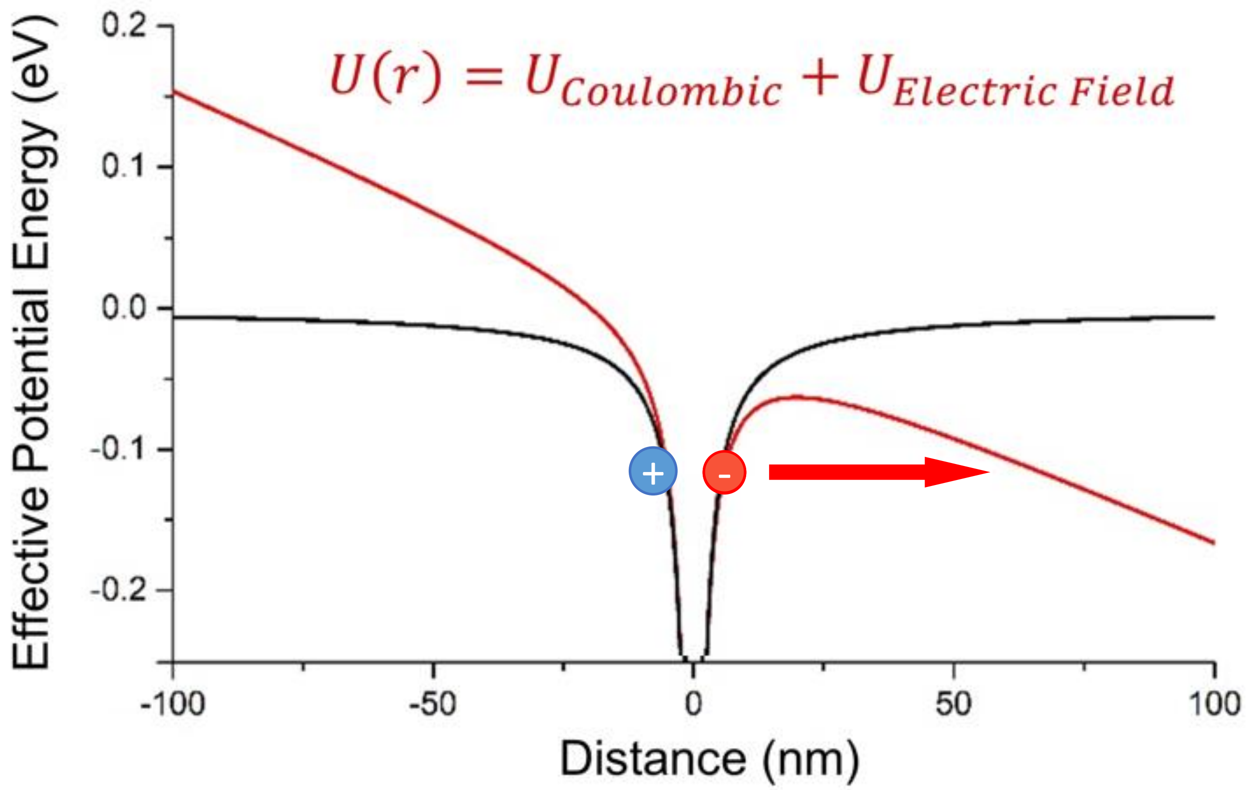


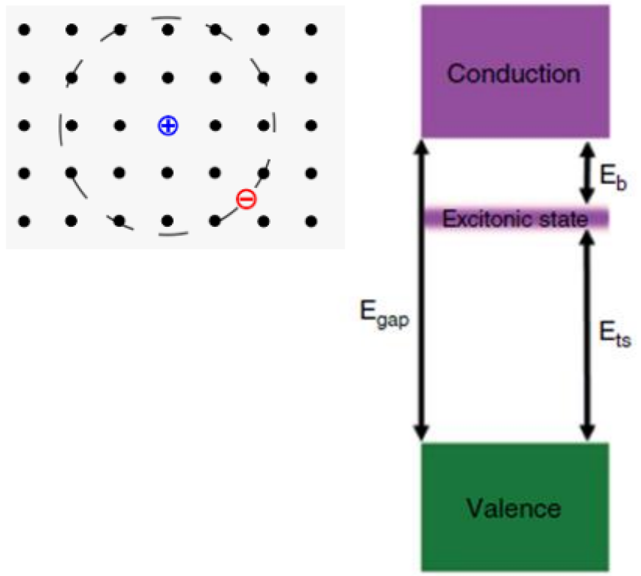
•GO flakes 1, 2, 5 and 6 show a degree of reversible fluorescence

•Upon removal of the field, the fluorescence intensity of a number of GO flakes become fully/partially restored!!!

- Fluorescence microscopy images were analyzed with ImageJ.

Theoretical analysis

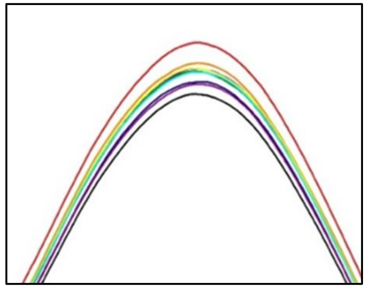




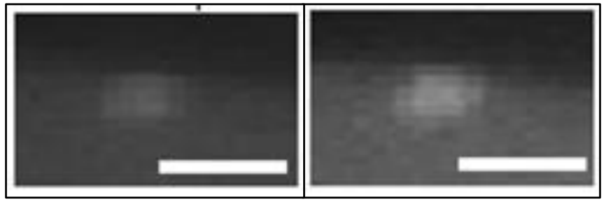
- Calculated potential well of the exciton without (**black line**) and with (**red line**) applied electric field (1.6 V/μm).
- Using the Wentzel, Kremer, and Brillouin (WKB) approximation, the transmission probability is **~5.2%** for the bulk GO sample.

Conclusions

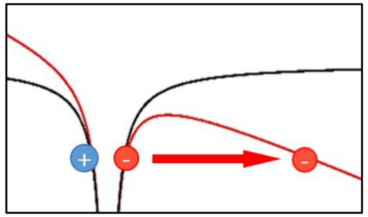
- We can control the intensity of GO fluorescence emission on the level of the bulk sample as well as a single flake



- Upon field removal, the fluorescence intensity of the majority of GO flakes fully or partially restored



- Based on the exciton model we calculated electron transmission probability of ~5.2% is a close estimate to the experimental 6% quenching for bulk GO sample



- Utilizing the electric fields as a mechanism to fine-tune optoelectronic properties of GO offers a degree of reversibility in device geometry.

Acknowledgments

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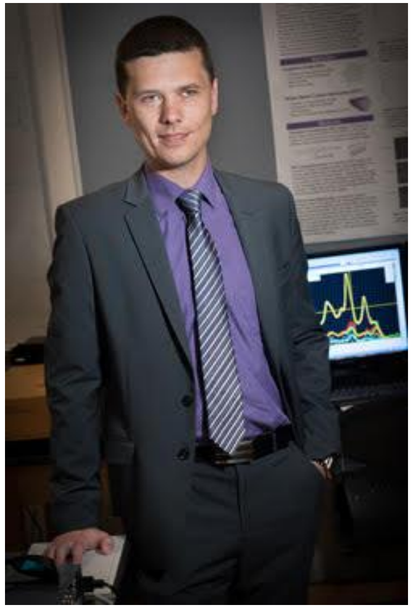

- Nowadays, with the advancement of technology and medicine people need to develop novel materials. And graphene oxide has become one of them. Graphene oxide is a very thin carbon sheet with some oxygen atoms on its surface. Because of that oxygen graphene oxide can emit light and, thus, can be used as a tiny lightbulb. In our work we show that the light from graphene oxide can be controlled by electricity and create a mathematical model to fully describe this effect. This phenomenon allows graphene oxide to be used as tiny dimmable lightbulbs in electronics.