REU Project: Fluorescence of Quantum Dots on a Graphene Substrate

Paul Davis
Advisor: Professor Ritchie
My Project

Goals

- Figure out how to use microscope and camera.
- Image Quantum Dots
- Image quantum dots on graphene
- Is there a difference between quantum dots on graphene and ones on glass?
- Possible reasons for quenching of dots’ fluorescence.
- Future Work
What is a Quantum Dot?

- Tiny Semiconductor
- Generally 2-10 nm in diameter.
- Perspective:
Uses of Quantum Dots

- Qubits for quantum computing.
- More efficient photovoltaic devices.
- Quantum Dot LEDs
- Can perform like traditional fluorescent organic dyes in biological imaging.
Quantum Dots as Fluorophores

- Versatile because...
  - Size determines color of fluorescence
  - Relatively easy to control size of quantum dots
  - Minimal photo bleaching
  - Good quantum yield
CdSe core/ ZnS shell
Fluorescence of Quantum Dots

- **Semi-Conductors**
  - Bands (Valence, Conduction)
  - Band Gap
  - Electron excitation and de-excitation
  - Photon Emitted

Bulk CdSe Band Gap Energy = 1.73eV
Specifically quantum dots

- Quantum Confinement

- Exciton Radius

- Bulk Semiconductor

- Exciton Radius

- Quantum Dot
Quantum dots as rainbow
Dots

- Often thick polymer coating ~20 nm
- Dots I used ~1 nm coating of maleimide a different linker.
- Allows closer contact with the graphene.
What I have been doing

First

- Learn to use microscope and camera
- Practiced with fluorescent beads
- Clean glass—create clear, background for imaging
- Dilute and prepare samples
- Learning to use Image J
Picture of Microscope, Light Source and Camera
Picture of Fluorescent beads

40X objective
100ms exposure
Second
- Get Illumination profile of beam spot.

All:
40X objective
100ms
exposure
Constant Intensity Profile

![Graph showing intensity profile over frame numbers](image)
Third
  ◦ Image quantum dots!!

40X objective
100ms exposure
Quantum Dots Video

Parameters of Images:
-100X objective
-30fps
-New test camera
Fourth
  - Find intensity of a single dot.

40X objective
100ms exposure
40% of Dots Viewed were single dots
What is Graphene? How is it made?

- One atom thick layer of carbon atoms arranged in a crystal lattice.
- Mechanical exfoliation
- Chemical Vapor Deposition (CVD) method
Bright Field Images of Graphene

Edge of Graphene

Middle of Graphene

Both:
40X objective
100ms exposure
Images of Quantum dots on Graphene...

- According to literature by Chen and Berciaud expect...

Chen Z.; Berciaud S. Energy Transfer from Individual Semiconductor Nanocrystals to Graphene. ACS Nano. 2010, 5, 2964-2968
Possibilities of how graphene quenches fluorescence

- Resonant Energy Transfer (FRET)

Molecule to Molecule:
resonance energy transfer
\[ E \sim r^{-6} \]

Molecule to 2D surface:
\[ E \sim r^{-4} \]
First attempts

40X objective
100ms exposure
Eventually

Dots on Graphene
100X objective
100ms exposure

Dots on Glass
100X Objective
100ms exposure
Future Work

- Continue to image dots on graphene
- Use dots of different radii
- Add electrodes to the graphene to control its electronic properties.