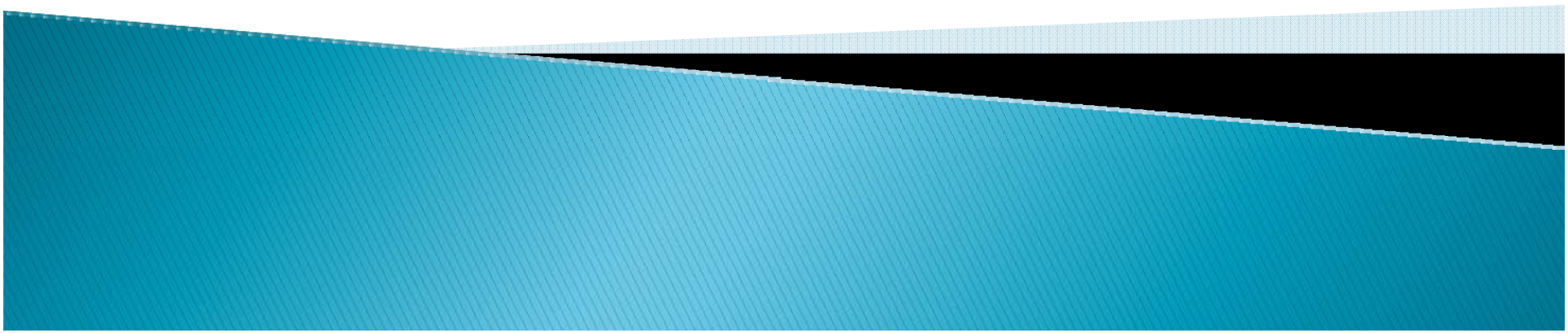
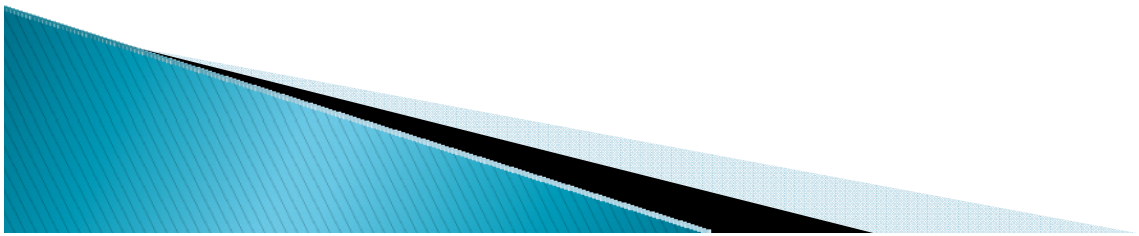
REU Project: Fluorescence of Quantum Dots on a Graphene Substrate

Paul Davis
Advisor: Professor Ritchie



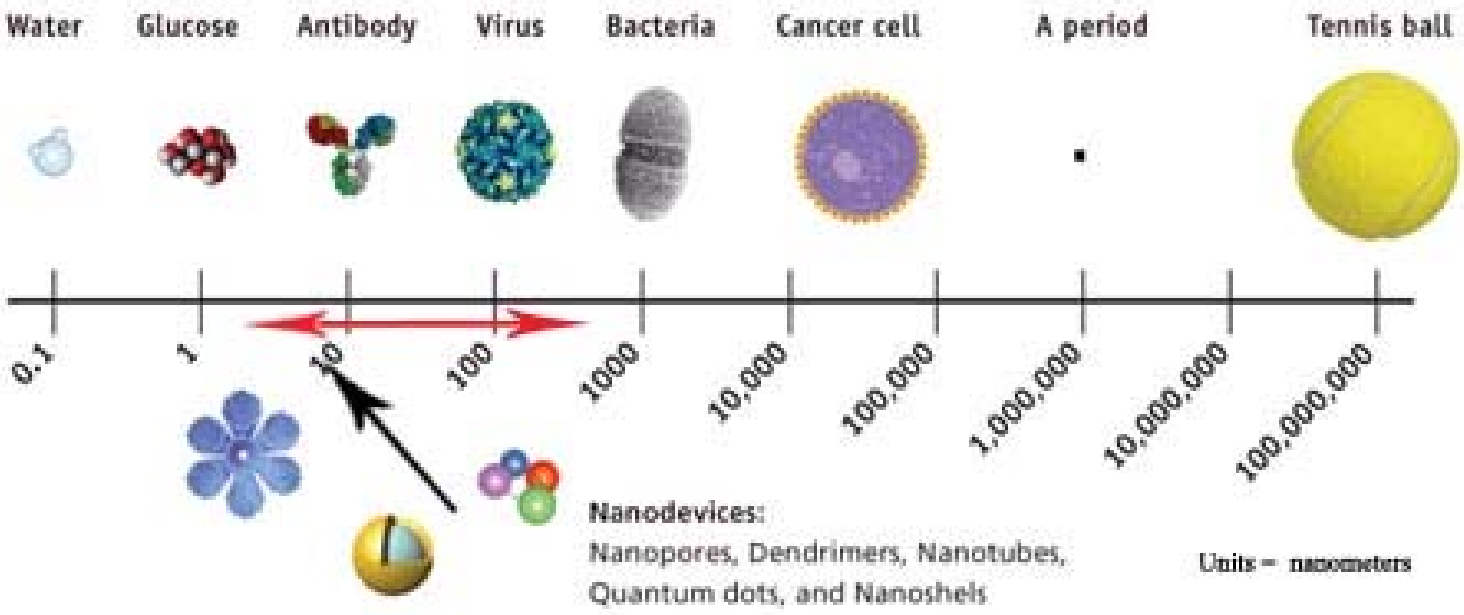
My Project

- 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?

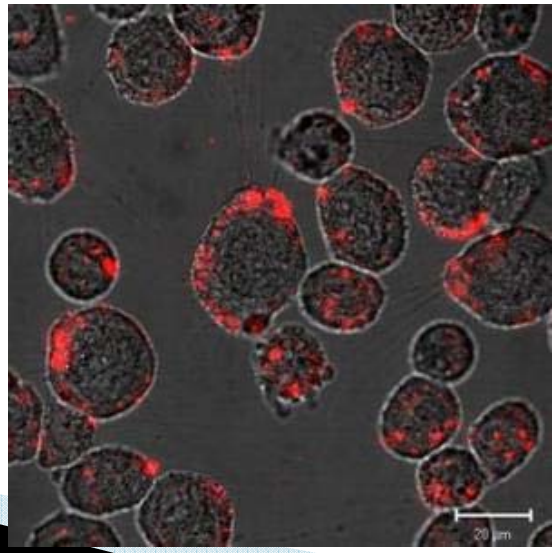
- Tiny Semiconductor
- Generally 2-10 nm in diameter.
- Perspective:



http://nano.cancer.gov/action/news/featurestories/monthly_feature_2005_aug.asp

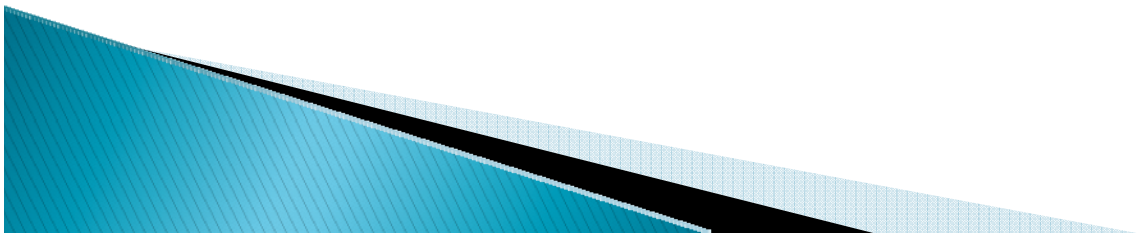
Uses of Quantum Dots

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

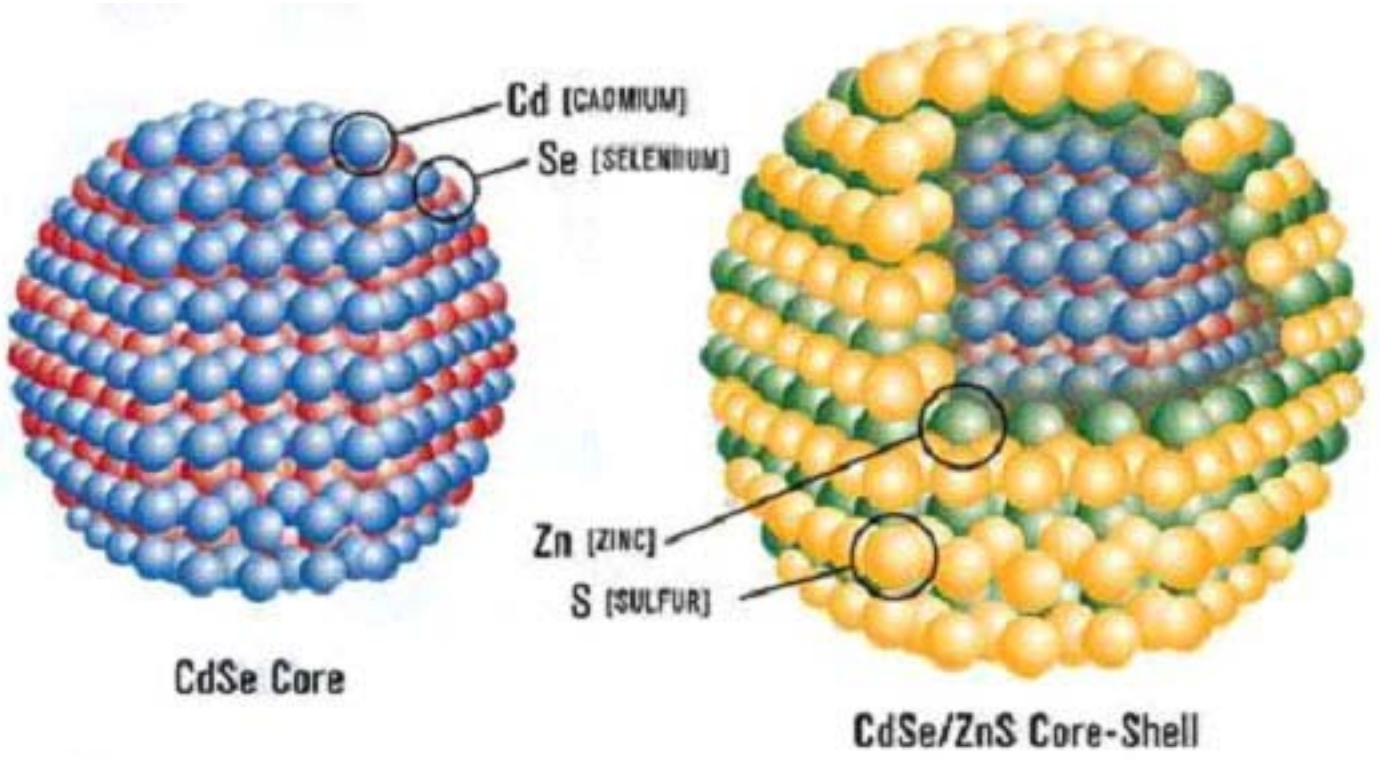


Quantum Dots as Fluorophores

- 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

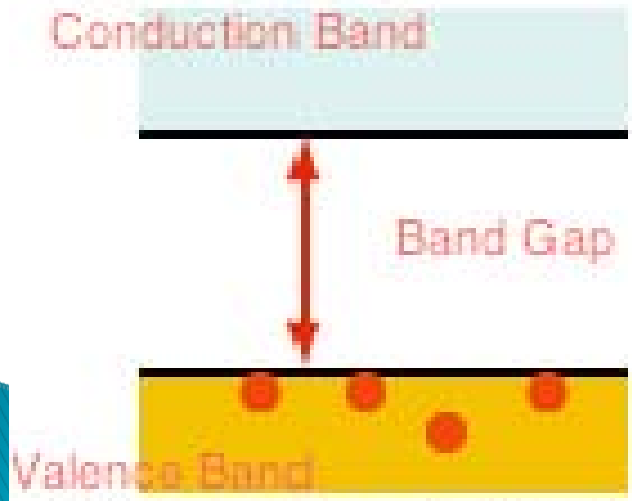


http://www.observatorynano.eu/project/filesystem/images/2ch.nc.1.p06.jpg

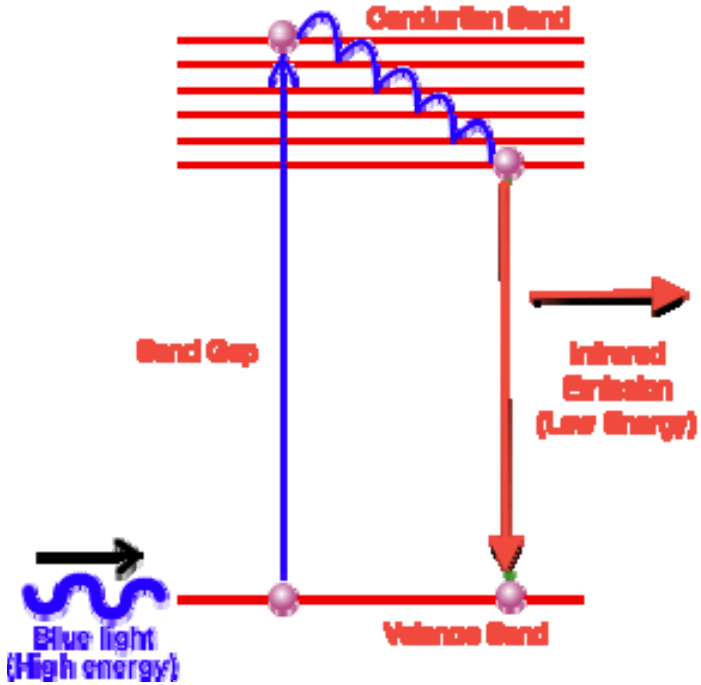
Fluorescence of Quantum Dots

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

Bulk CdSe Band Gap Energy = 1.73eV

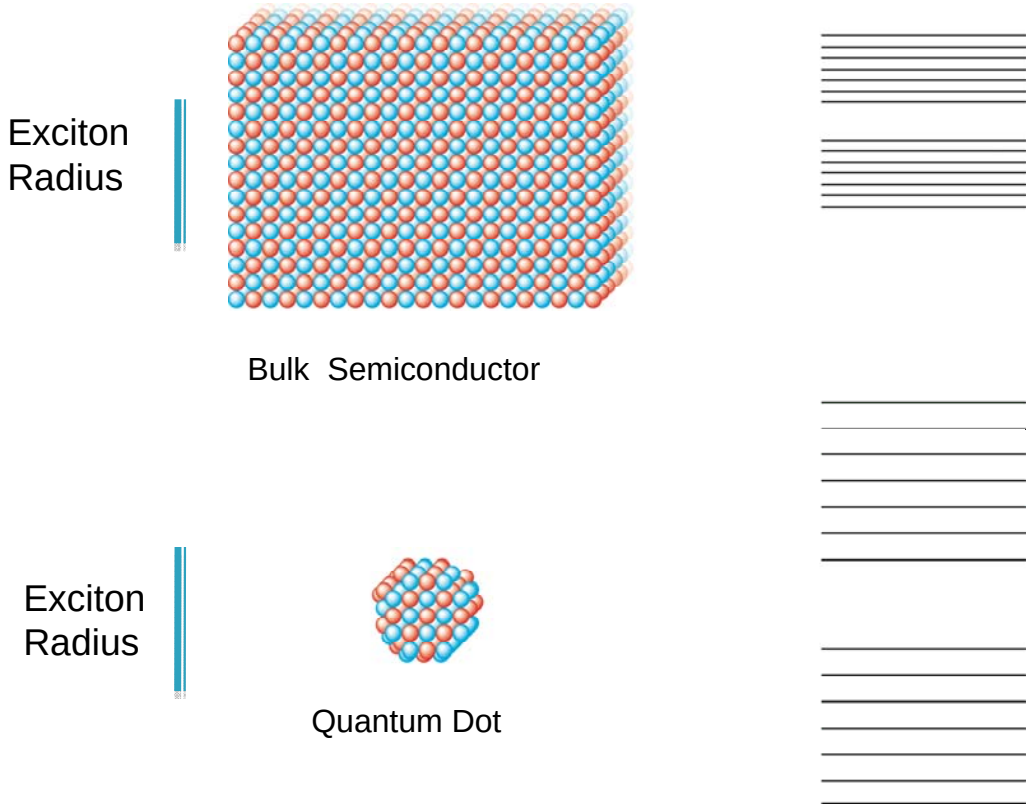


(b) semiconductor

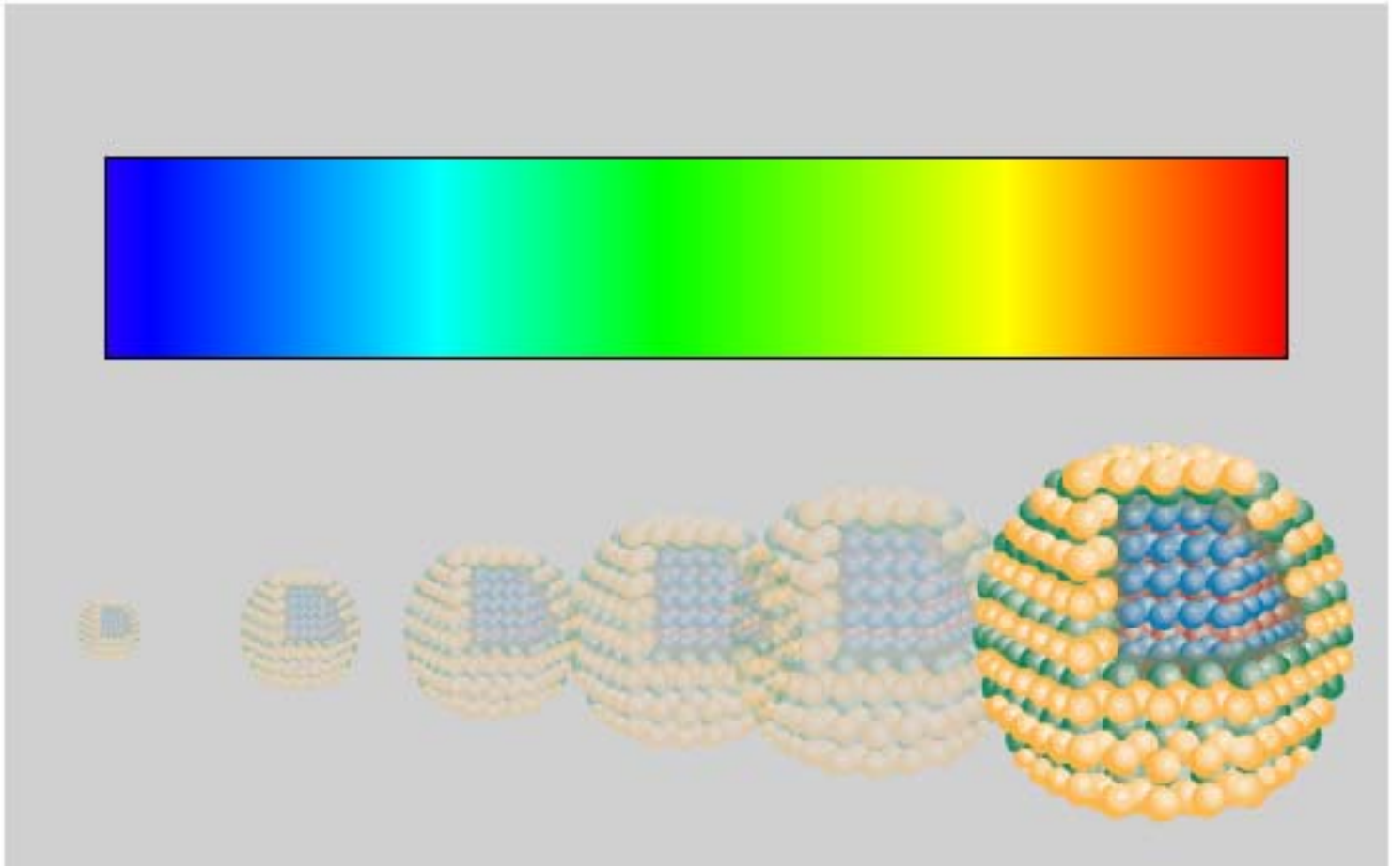


Specifically quantum dots

- Quantum Confinement

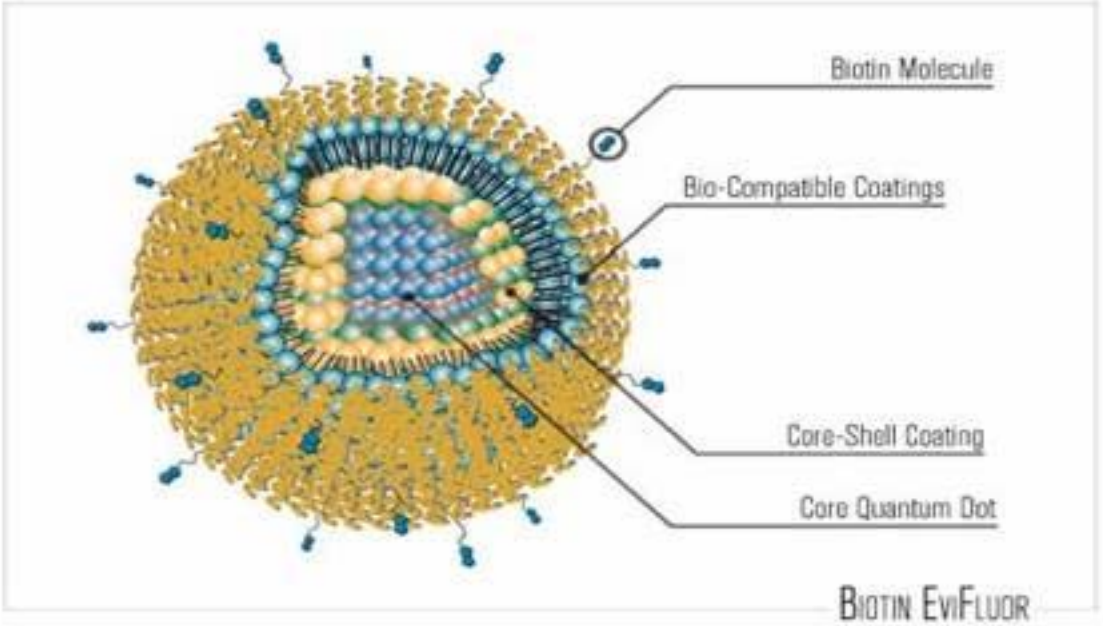


Quantum dots as rainbow



Dots

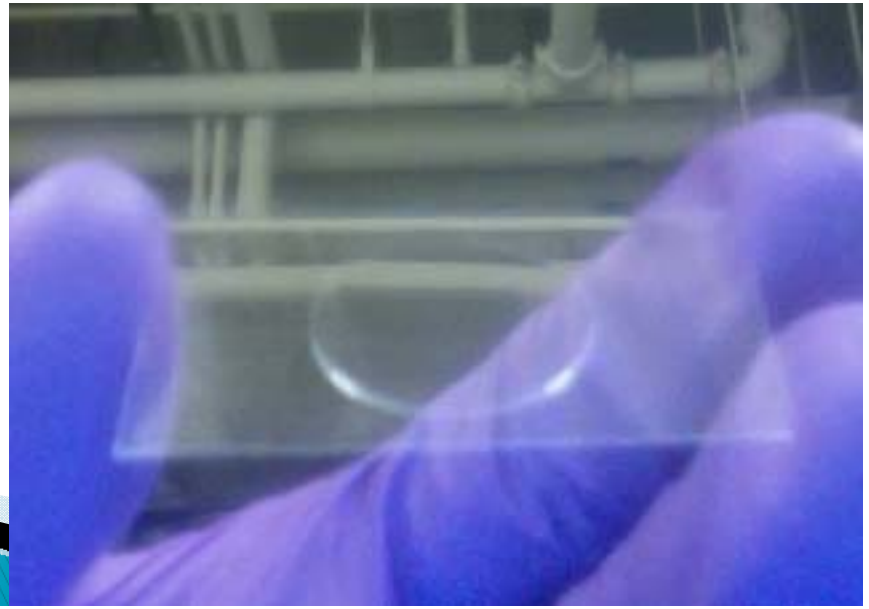
- Often thick polymer coating ~20 nm
- Dots I used ~1nm coating of maleimide a different linker.
- Allows closer contact with the graphene.



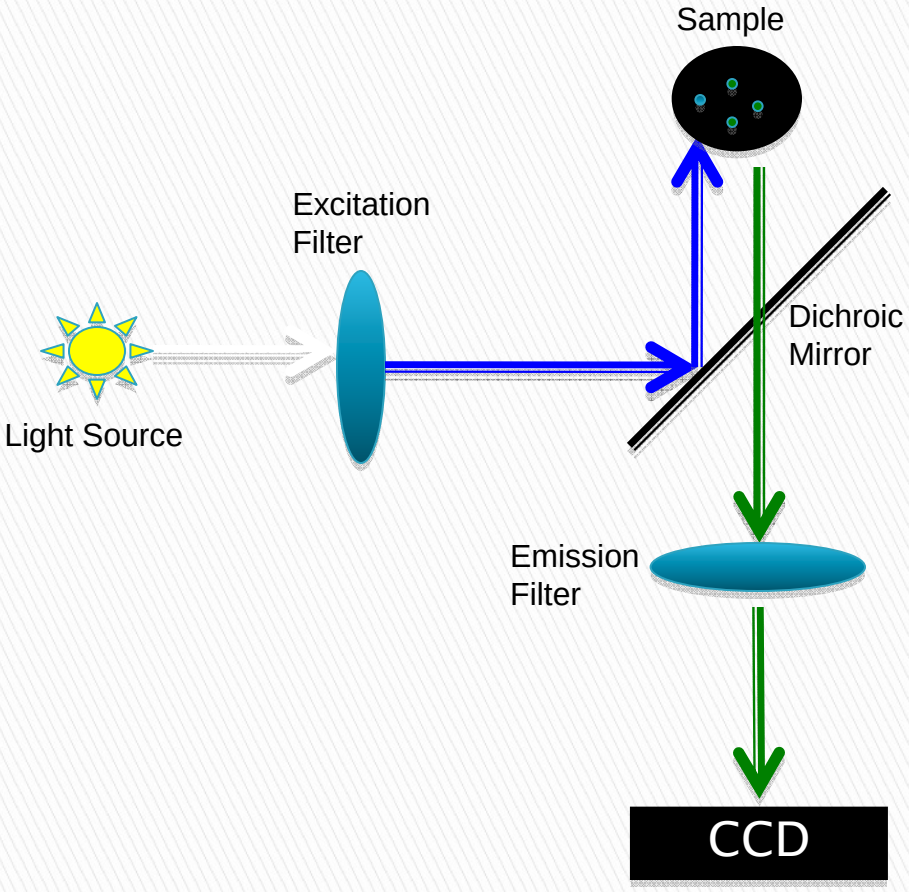
http://www.pharmainfo.net/reviews/quantum-dots-novel-technique-drug-delivery-and-therapy

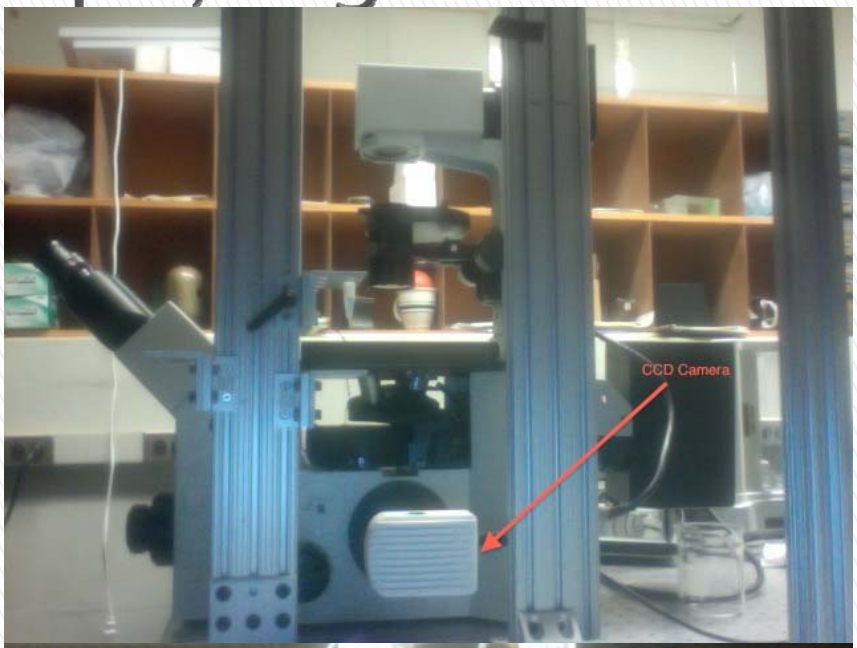
What I have been doing

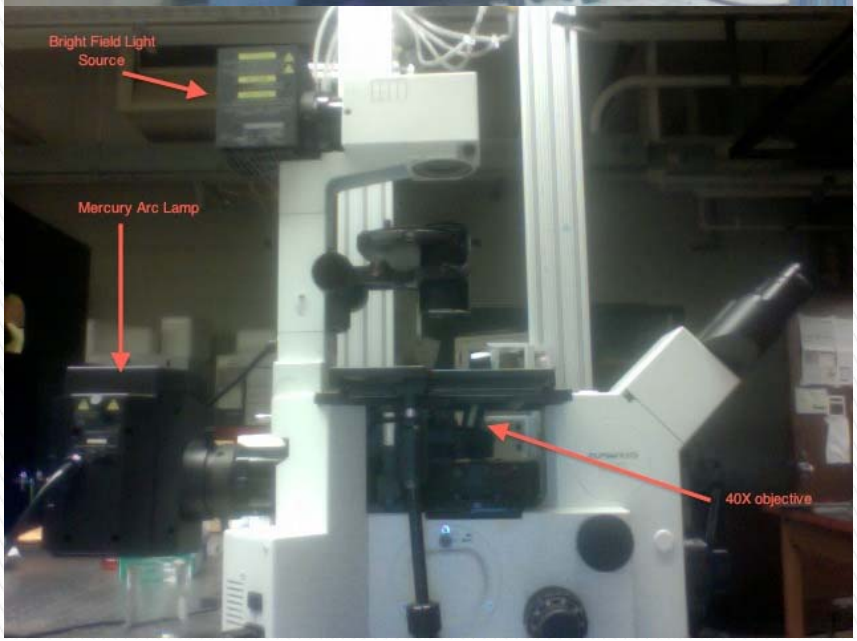
- First
  - Learn to use microscope and camera
  - Practiced with fluorescent beads
  - Clean glass- create clear, background for imaging
  - Dilute and prepare samples
  - Learning to use Image J



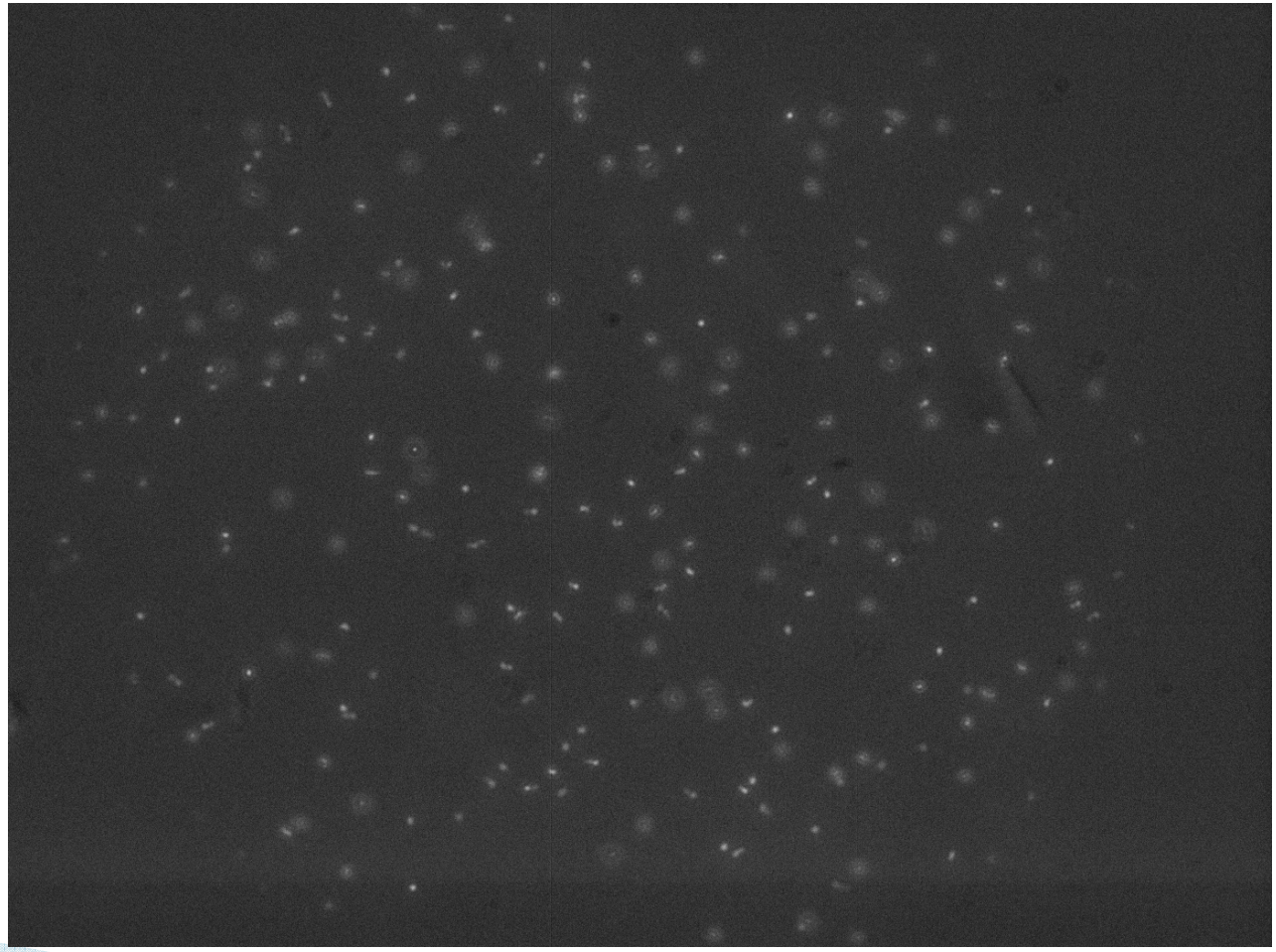
Picture of Microscope, Light Source and Camera







Picture of Fluoroescent beads

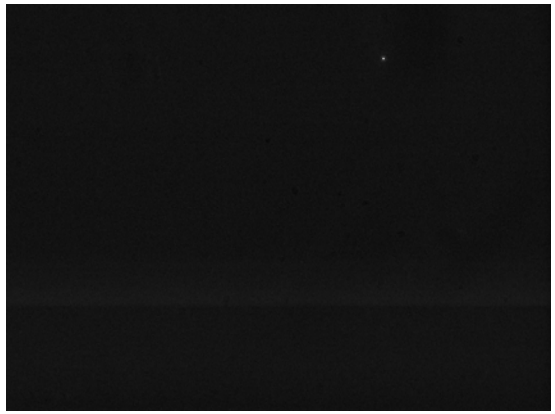


40X objective
100ms exposure

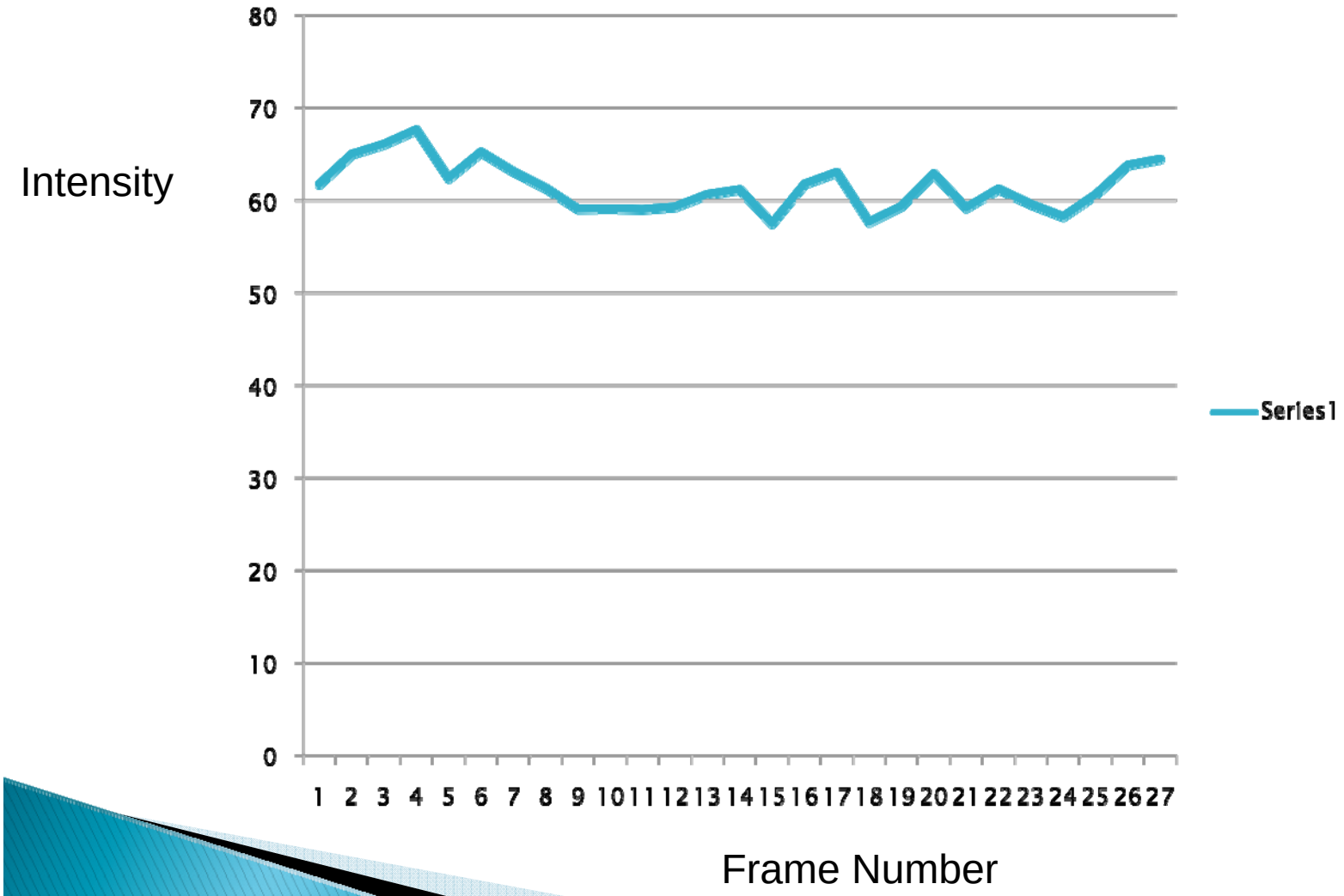
- Second
  - Get Illumination profile of beam spot.



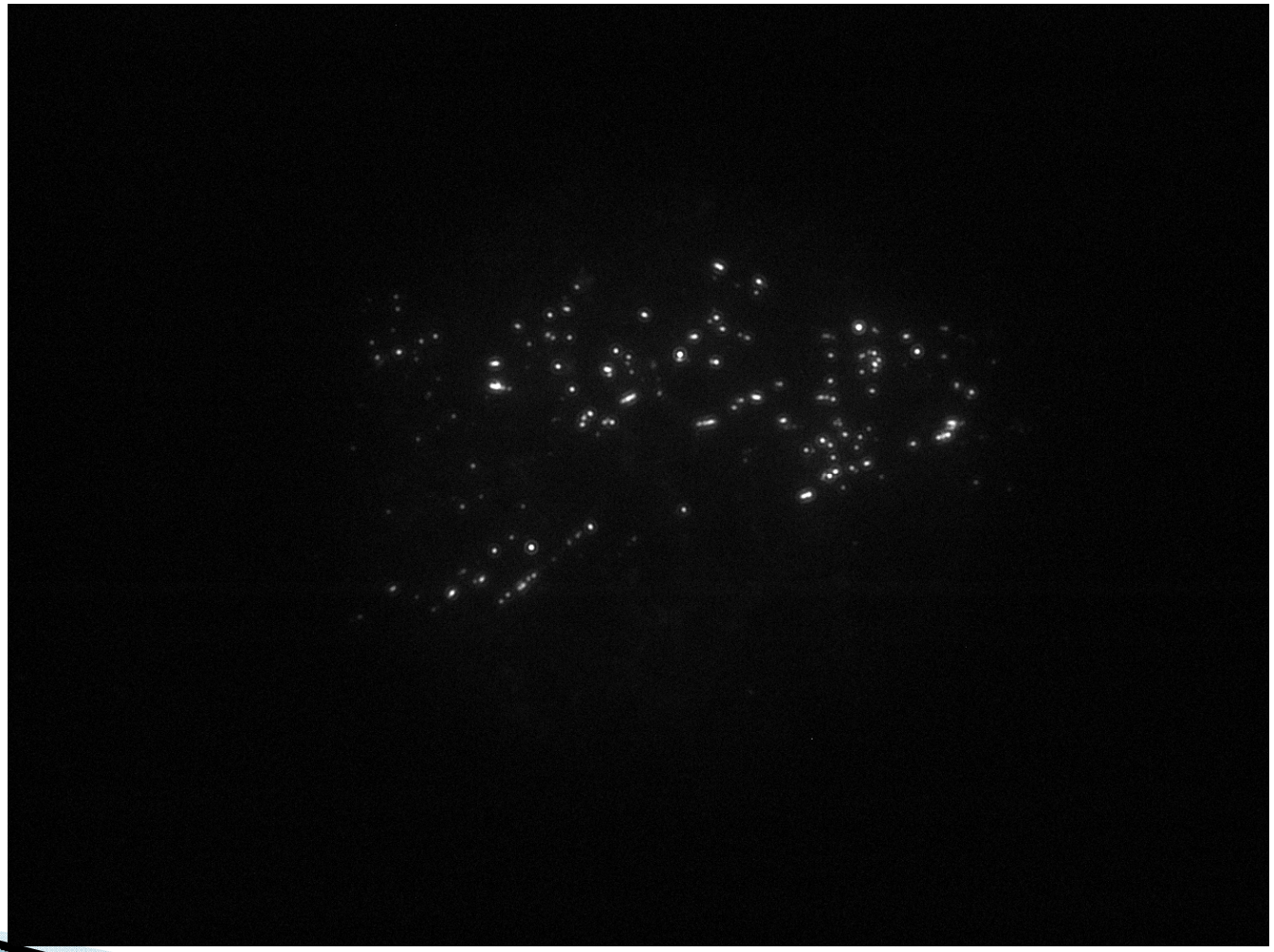
All:
40X objective
100ms
exposure

Constant Intensity Profile



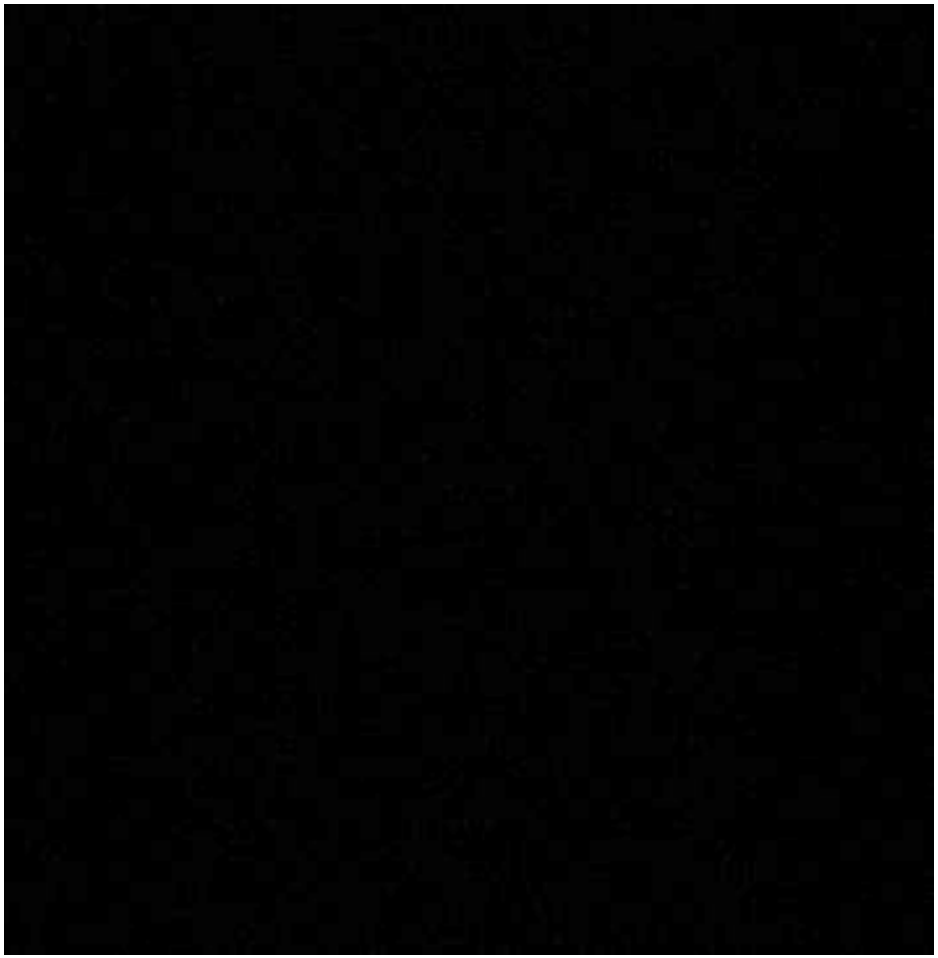
- Third
  - Image quantum dots!!



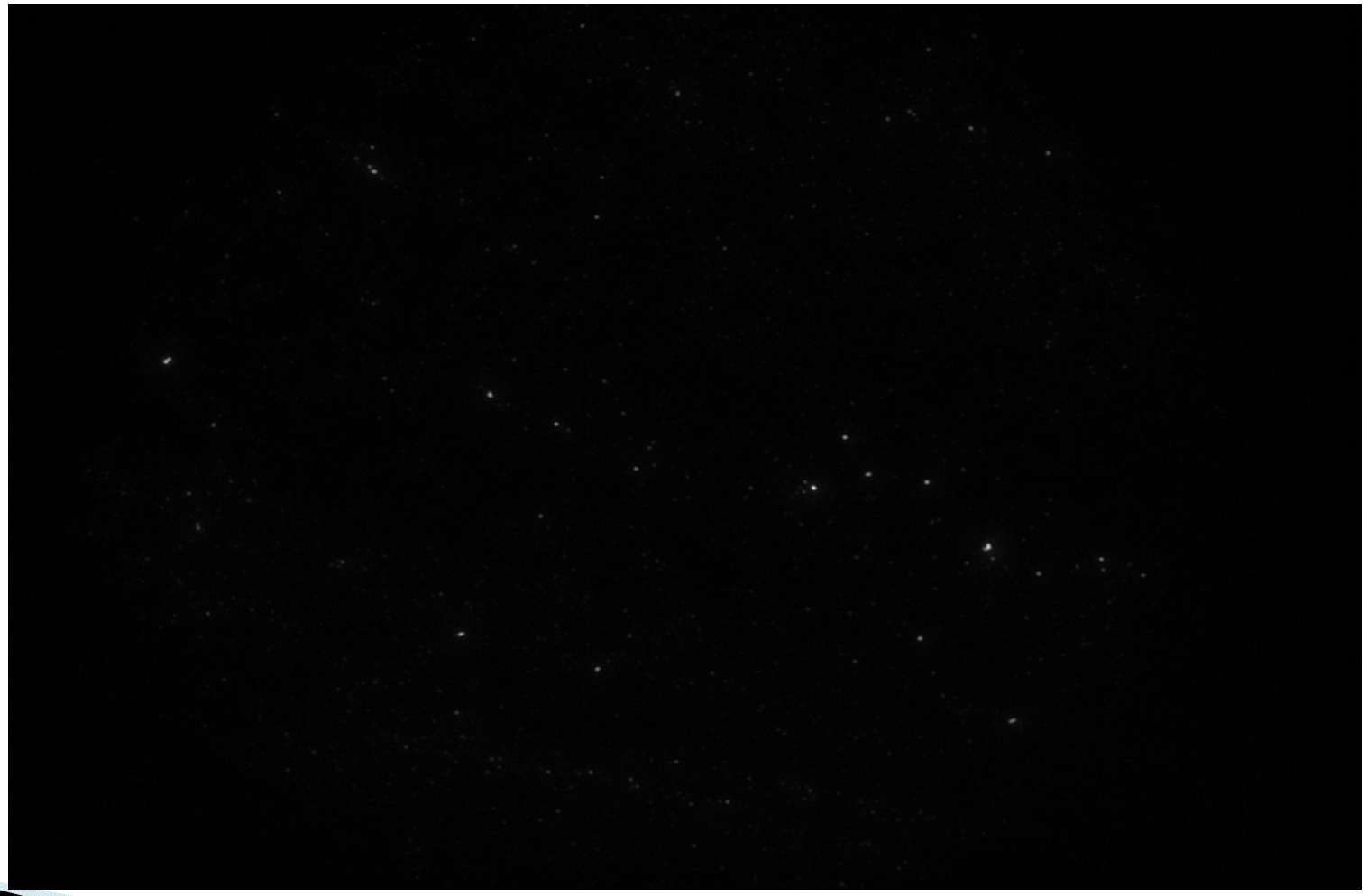
40X objective
100ms exposure

Quantum Dots Video

Parameters of Images:
-100X objective
-30fps
-New test camera



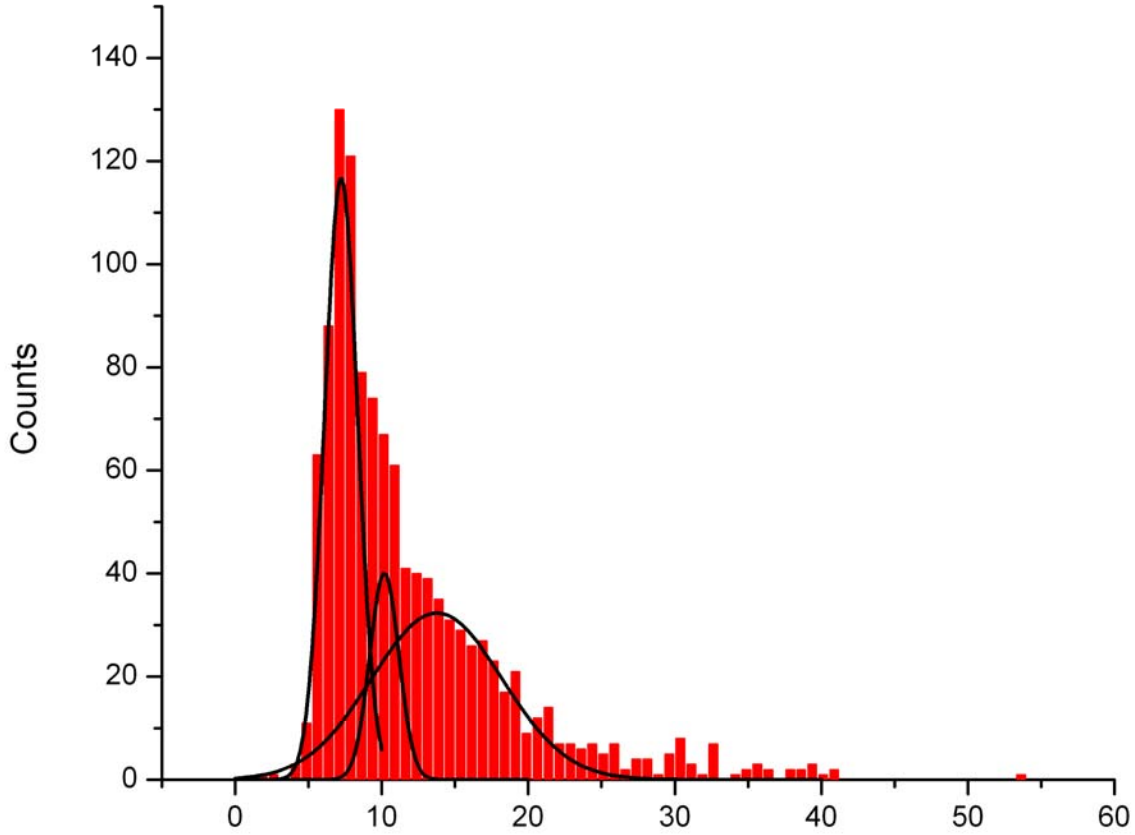
- Fourth
  - Find intensity of a single dot.



40X objective
100ms exposure

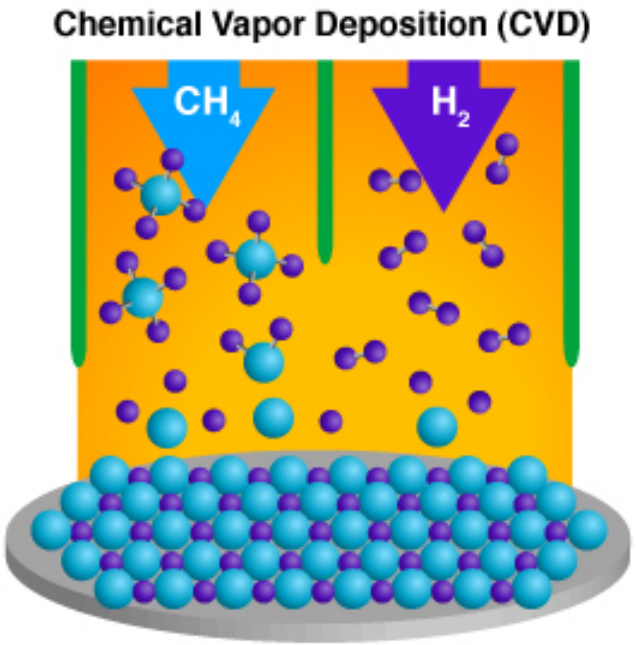
Single Quantum Dot Data

40% of Dots Viewed were single dots



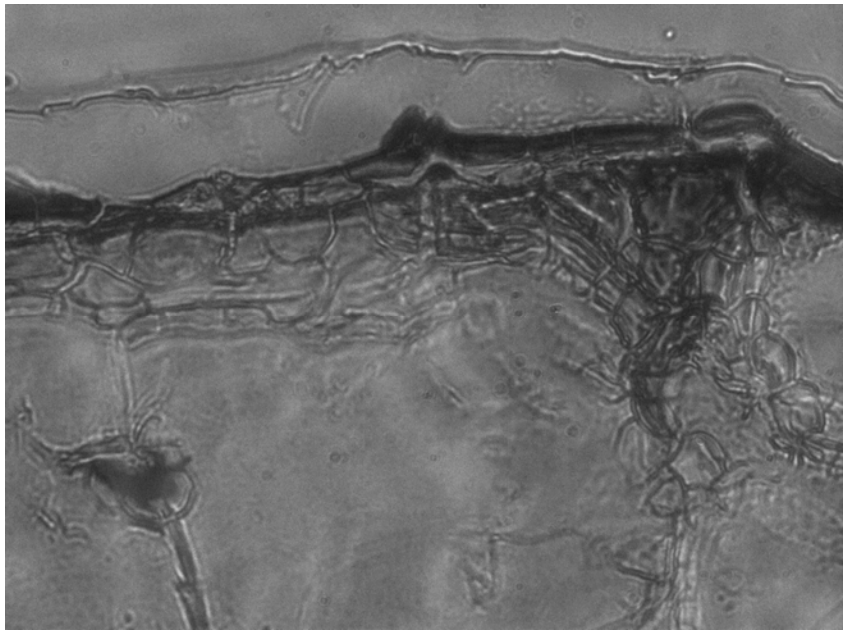
What is Graphene? How is it made?

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

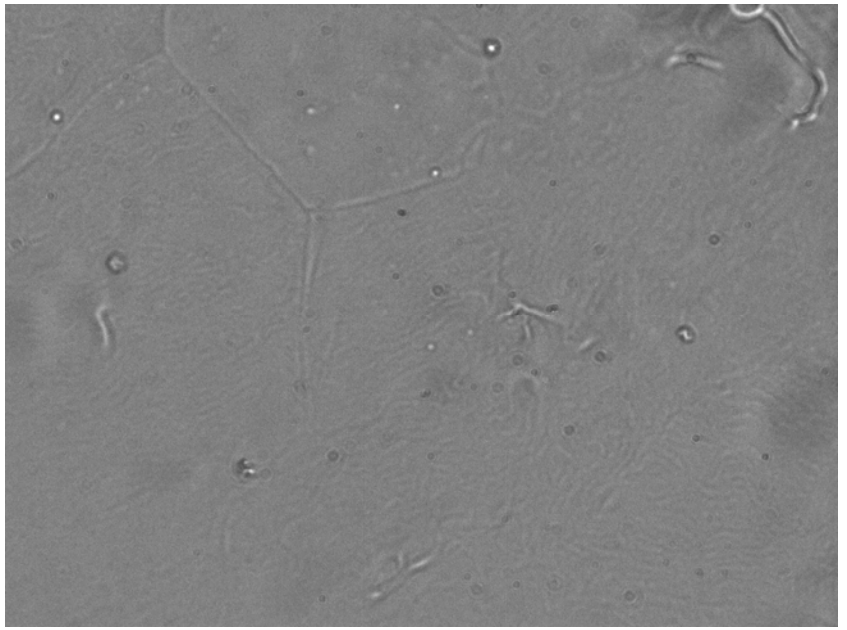


http://itech.dickinson.edu/chemistry/wp-content/uploads/2008/04/pg02.jpg

Bright Field Images of Graphene



Edge of Graphene

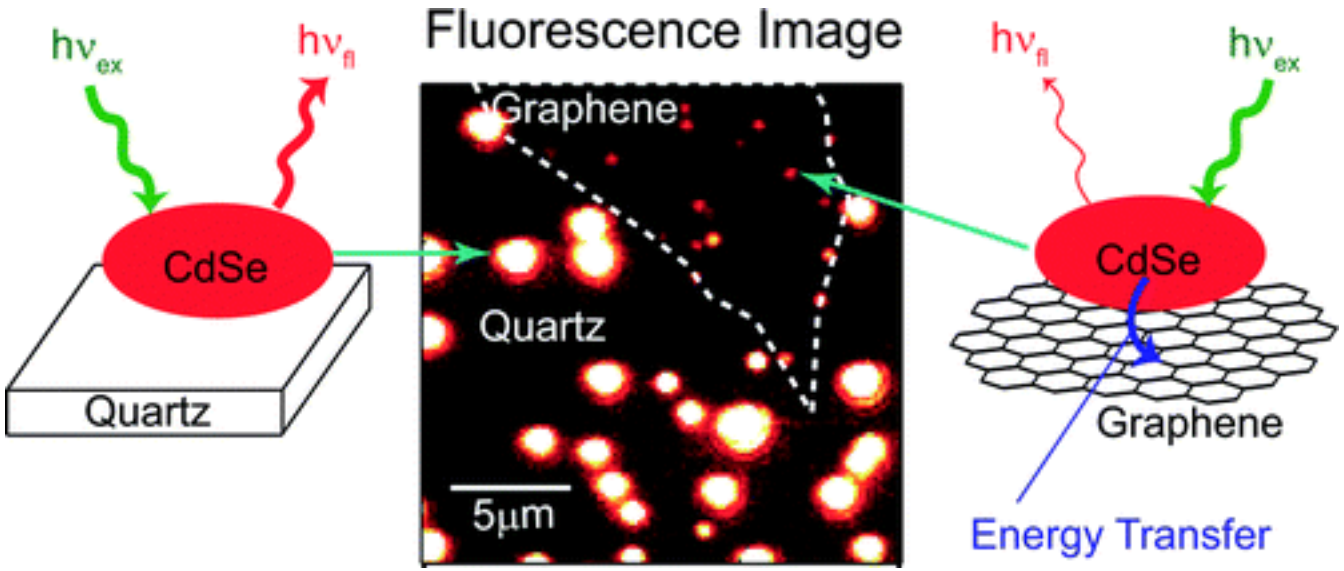


Middle of Graphene

Both:
40X objective
100ms exposure

Images of Quantum dots on Graphene…

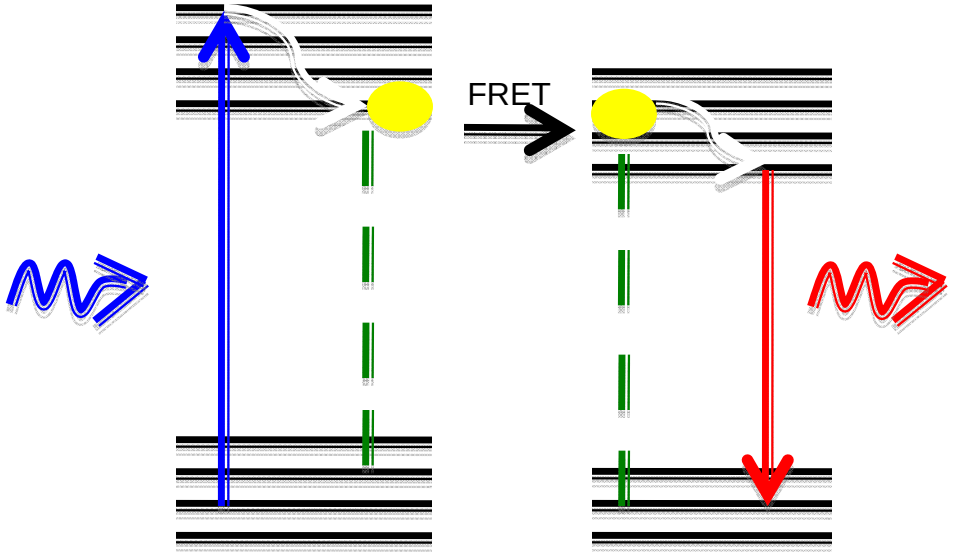
- According to literature by Chen and Berciaud expect…



Chen Z.; Berciaud S. Energy Transfer from Individual Semiconductor Nanocrystals to Graphene. ACS Nano. 2010, 5, 2964-2968

Possibilities of how graphene quenches fluorescence

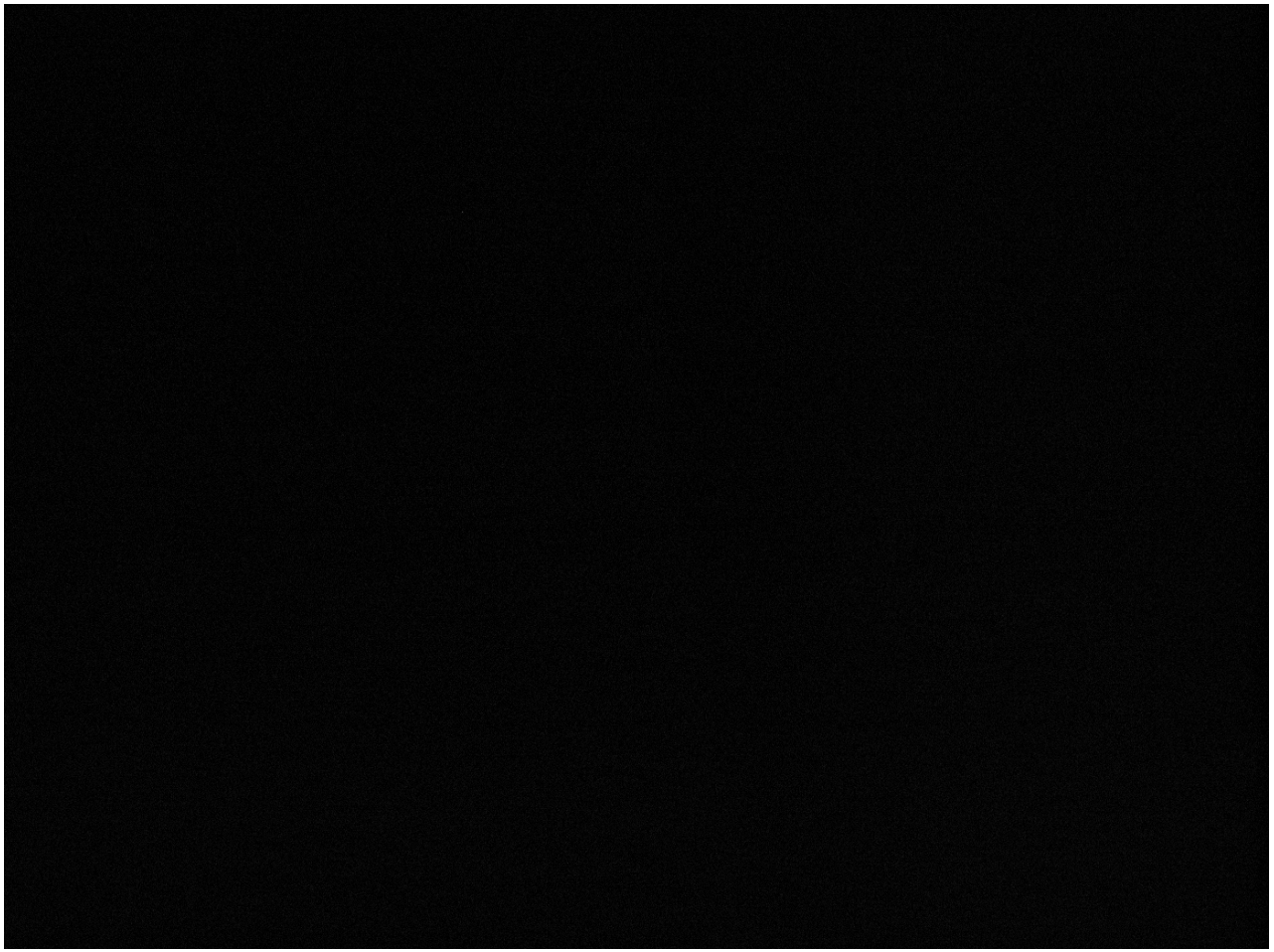
- Resonant Energy Transfer (FRET)



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

Molecule to 2D surface:
$E \sim r^{-4}$

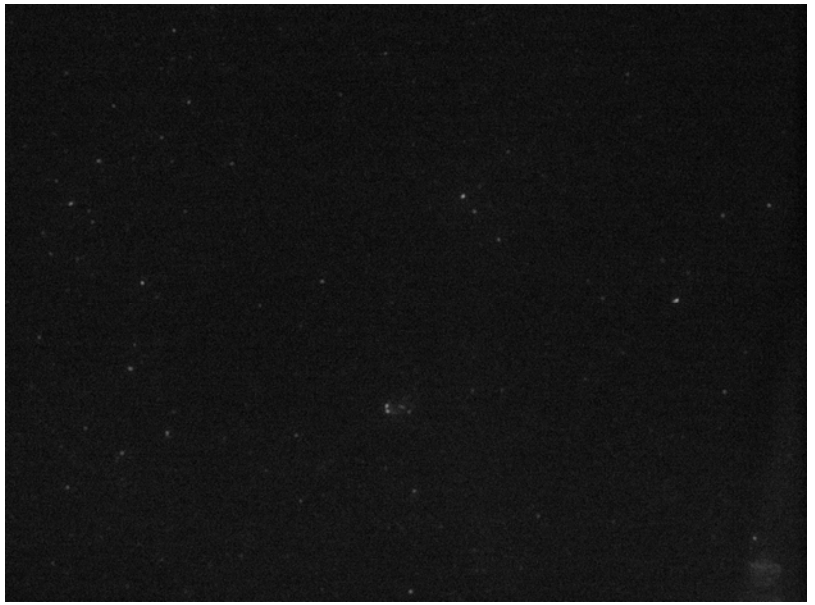
First attempts



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.