Time Resolved Photoluminescence of Quantum Dots

Garrett Rodriguez
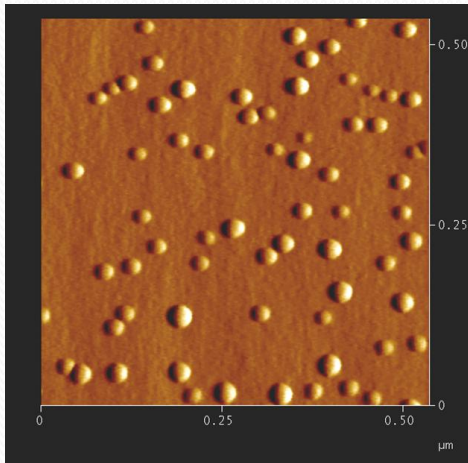
Vanessa Sih Research Group
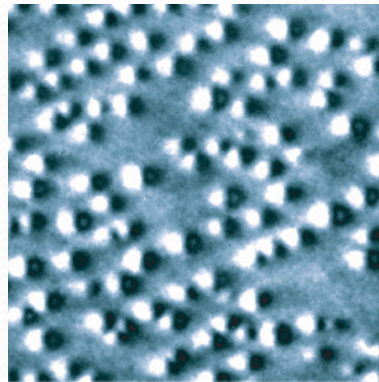
What Is A Quantum Dot?

- From Wikipedia, "A **quantum dot** is a portion of matter (e.g. semiconductor) whose excitons are confined in all three spatial dimensions"

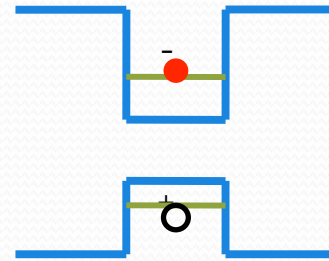- Similar to a quantum well, but quantum wells are only confined in one dimension

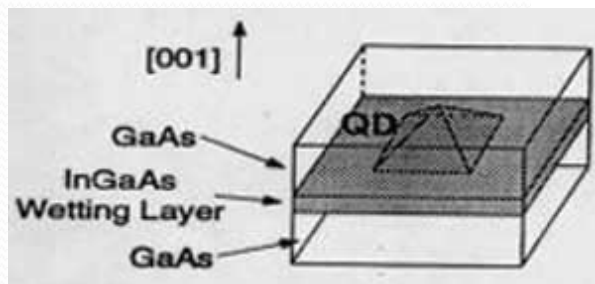# What Is A Quantum Dot?

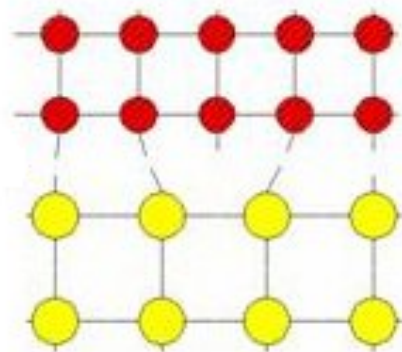essential-research.com

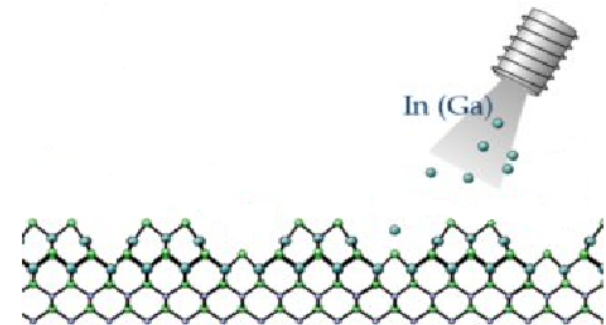elec-intro.com

How Are Quantum Dots Formed

- In a vacuum chamber, substrate is held at one end
- Dot material is heated to be shot at the substrate and adheres
- Lattice mismatch forms quantum dots

engin.umich.edu

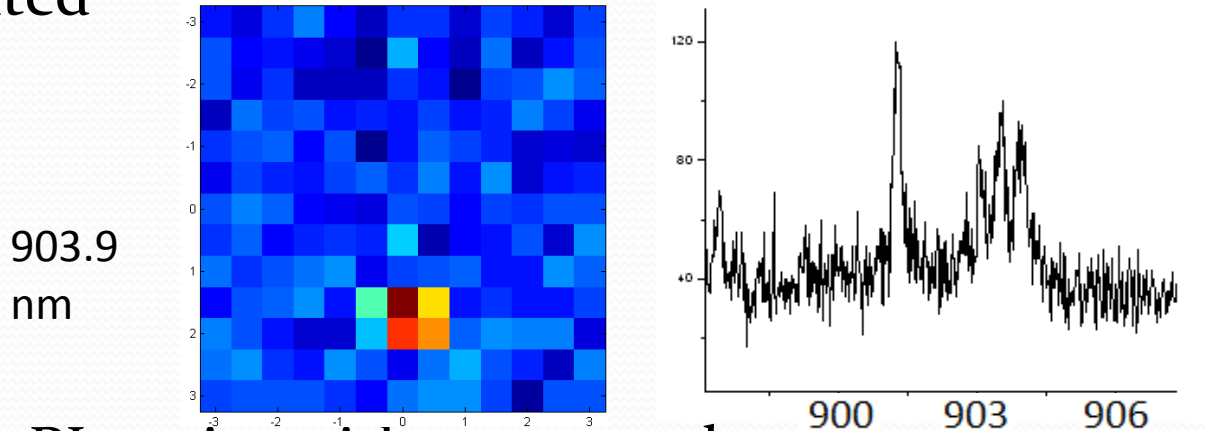ieap.uni-kiel.de

penev.objectis.net

Our Samples

- Our samples end up looking something like this
- This is a fragment cleaved off of a chip
- It contains many quantum dots

Time Resolved Photoluminescence

- Quantum dots emit photons when their electrons are excited

903.9 nm

- This PL varies with power and temperature

- The experiment that I have been working on explores how much time it takes for an electron to go from the valence band to the conduction band and back, so that the electron can be re-excited.

Experimental Setup
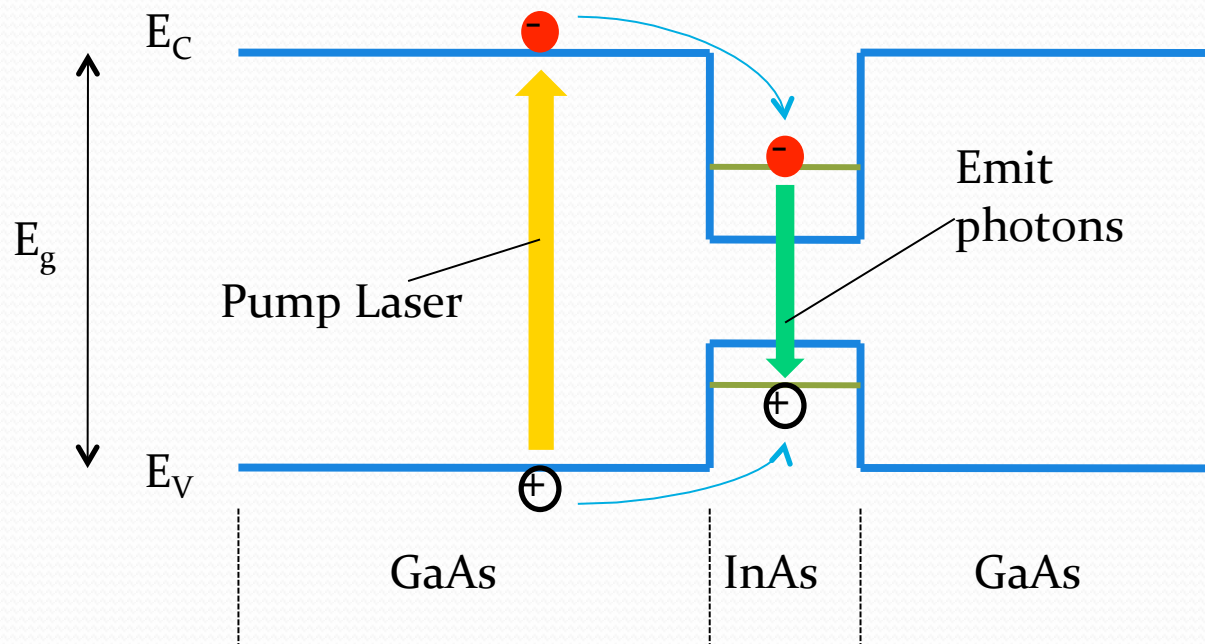
Experimental Setup

- Three Lasers
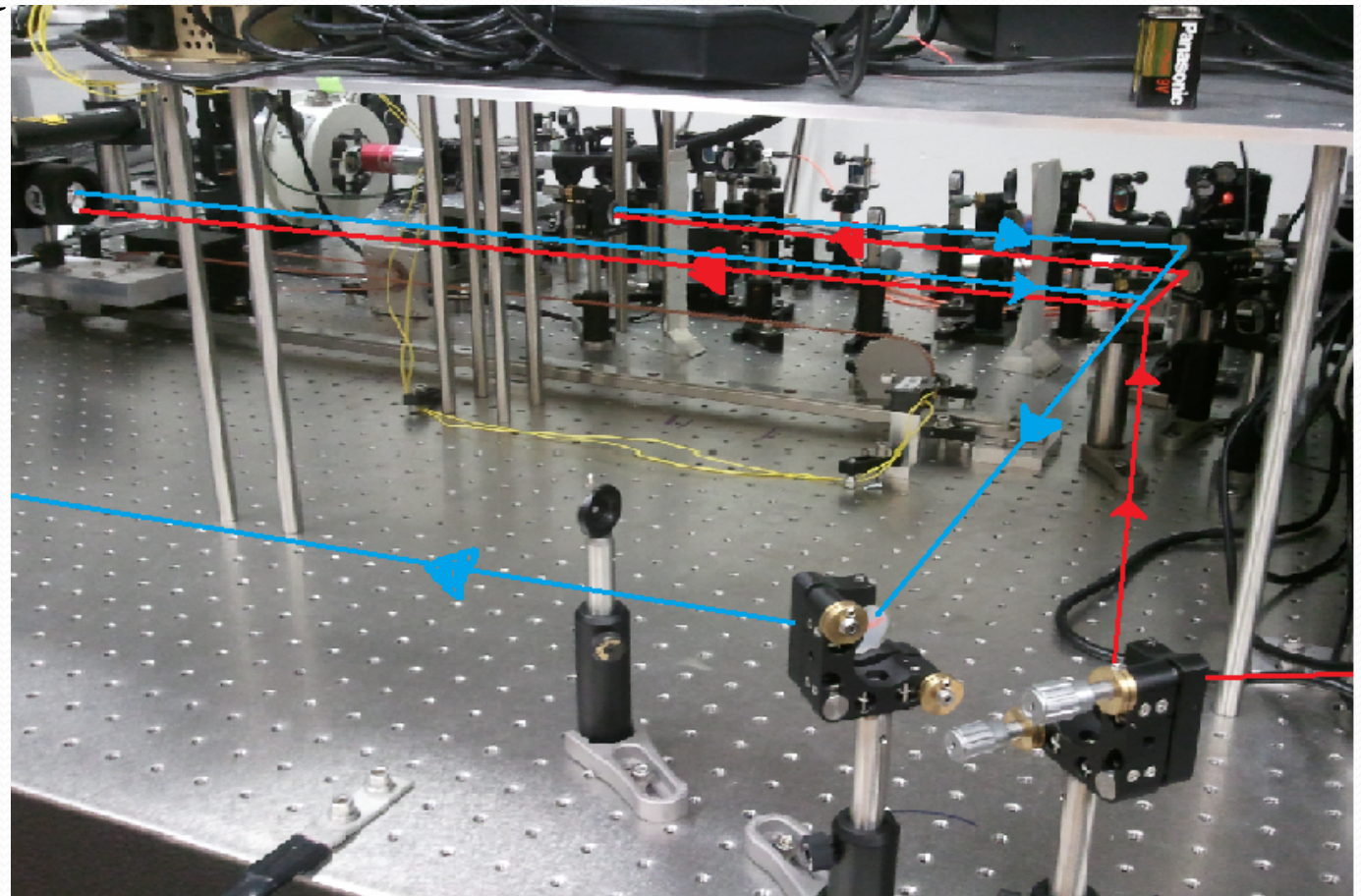- Fiber Laser
- HeNe Laser- 5mW
- Ti:Saph Pulse Laser-Tunable
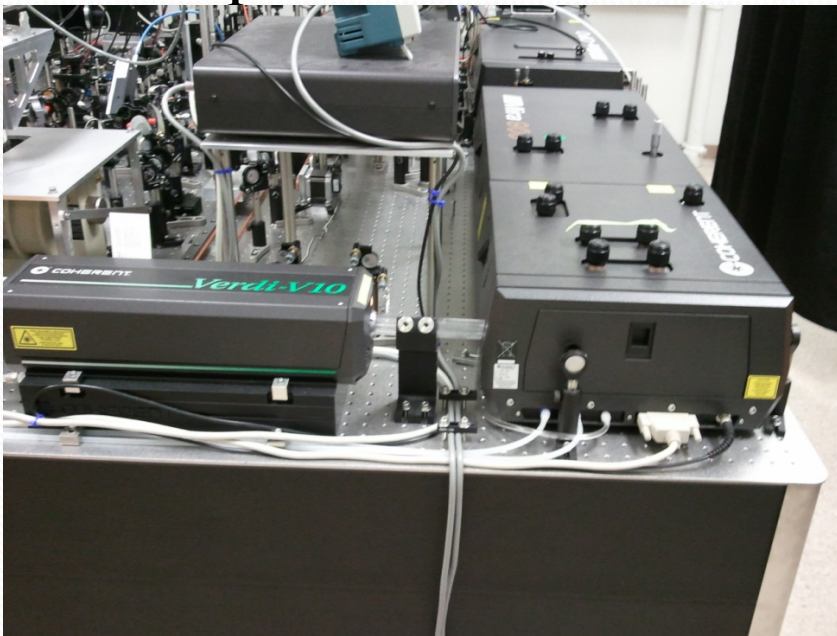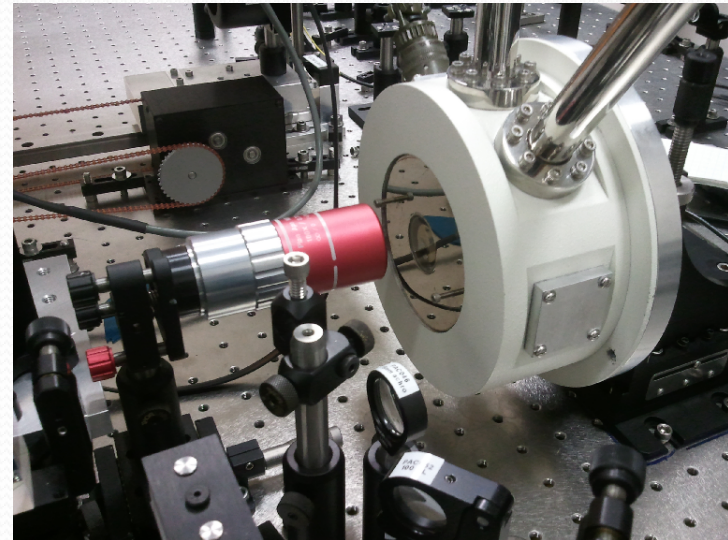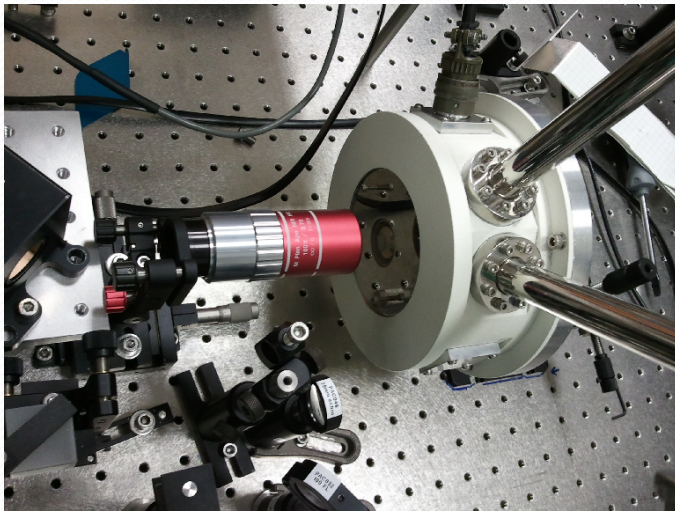
Experimental Setup

- Delay Line

Experimental Setup

- Resolution of delay line- 139 femtoseconds
- Around 2.5 nanoseconds maximum delay
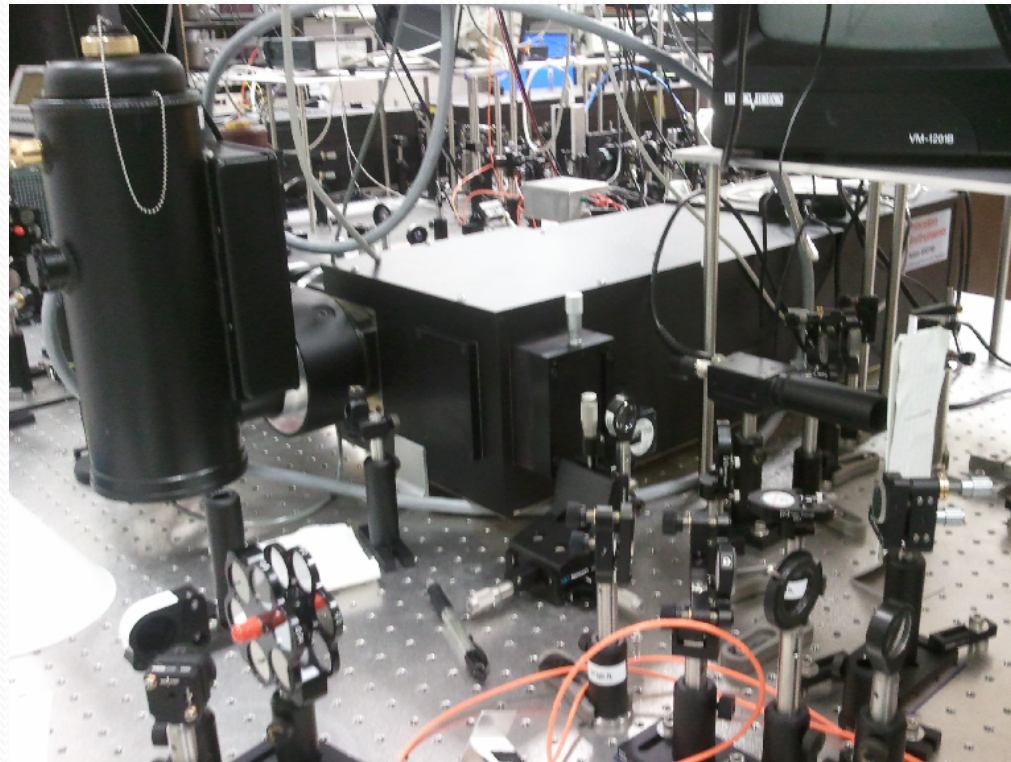- Expected relaxation time is 100ps-1ns

Experimental Setup

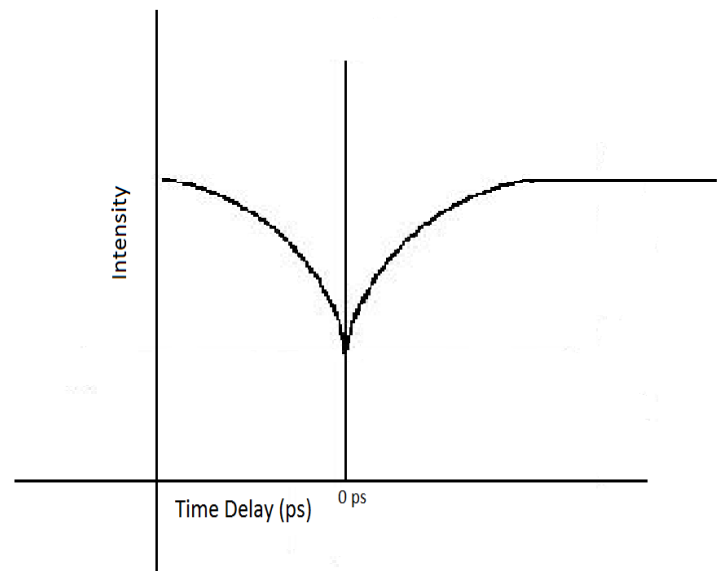- Objective allows us to focus the laser on the sample

Experimental Setup

- Charge Coupled Device
- Uses a diffraction grating to image spectrum

What we expect to see

- If the electron has relaxed back to the ground state when the second pulse hits then it will be re-excited and emit another photon.

- We expect to see a minimum at o delay rising to a maximum

Why Is This Important

- This will give us experimental results of the relaxation time of an electron in a quantum dot.

- This determines how quickly operations using quantum dots can be completed

Applications of Quantum Dots

- Photovoltaic cells
  - Layering quantum dots to absorb different wavelengths is useful

- Quantum processing
  - Storing/transferring information

- Use in diode lasers

- Transistors

1.5 ML (InAs)

180 ML (GaAs)

s

GaAs Buffer
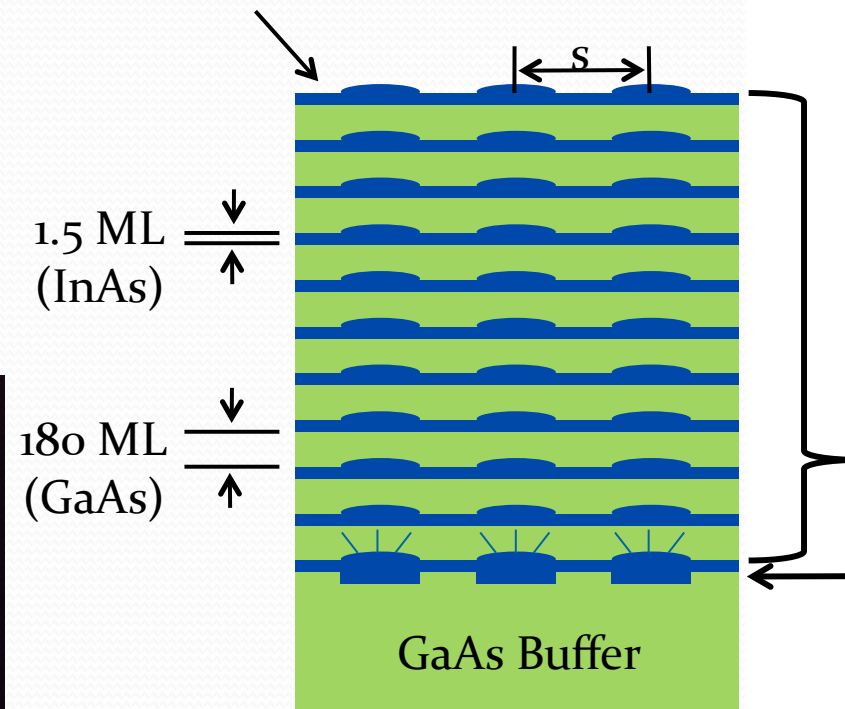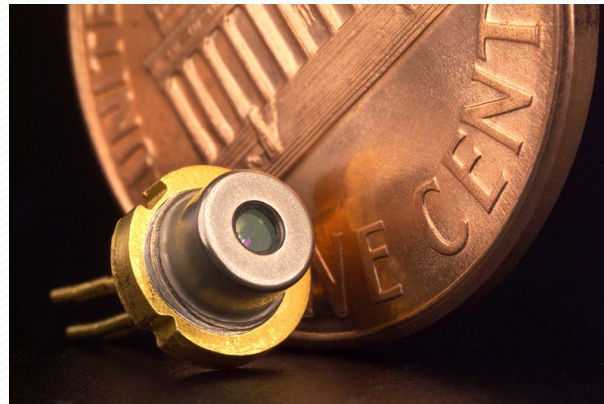
Acknowledgements

- I would like to thank
  - Vanessa Sih
  - Tim Saucer
  - Jieun Lee
  - The University of Michigan