Micro-photoluminescence and Raman spectroscopy setup

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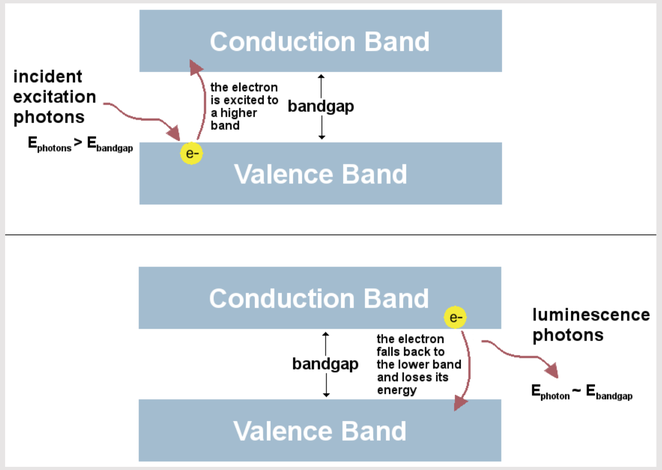
Introduction

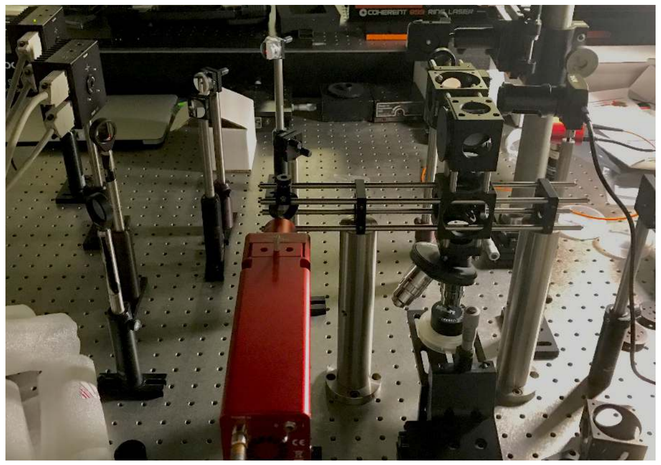
- The goal of the project was to build a micro-PL and Raman spectroscopy system
- This system allows one to identify material characteristics, like semiconductor bandgap, molecule type or chemical bonding
- photoluminescence (PL):
  - when atoms interact, electrons form bands of energy levels with bandgaps
  - aiming photons of higher energy than bandgap at a material excites electrons to a higher band
  - as electrons fall to a relaxed state, they lose energy in the form of emitted photons, or PL
- Raman effect:
  - phonons carry vibrational energy of a crystal structure
  - aiming high energy photons at a material excites the phonons
  - some of the photons lose energy and exhibit inelastic scattering (Raman effect)
- micro-PL and micro-Raman spectroscopy deals with collecting PL and Raman spectroscopy from micron sized features



A visual representation of the mechanism for photoluminescence.

Methods

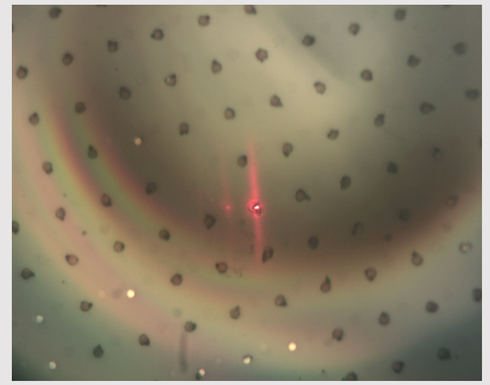
- I designed and built the system keeping in mind the optical path and the mechanics of the parts:



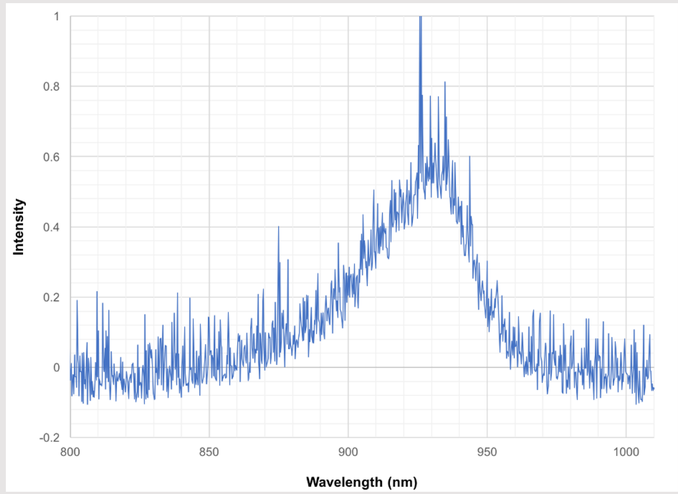
A photo of the micro-PL and Raman setup. Laser and white light enters the system onto the sample on the stage. PC: Sarah Moon

- A 658 nm (red) laser was aligned to enter the system and induce the PL and Raman effect on the sample
- A white light source was added to illuminate the sample to allow it to be imaged by the camera
- Using neutral density (ND) filters and mirrors, the laser and white light beams are reflected and transmitted to the sample and then to the spectrometer and camera
- 20X and 100X microscope objectives were added to focus the laser and white light onto a desired area of the sample
- Lenses focus the PL/Raman scattered photons and white light to a spectrometer and a camera
- A CMOS camera was installed to allow a zoomed-in view of the sample and the laser hitting the sample
- A spectrometer collects the PL and Raman scattered photons emitted from the sample
- Sensors on the spectrometer detect the intensity of incoming light at 2 nm wavelength intervals
- Intensity of incoming light (count of photons) vs. wavelength of light is plotted by a program
- An isolated increase in intensity on the graph after blocking the laser usually indicates the desired result (PL or Raman effect)

Results



An image of a sample with 5um radius InP dots and incident laser light taken by the camera using the 20X objective lens. PC: Sarah Moon



A graph of the PL from the same InP sample collected by the system using a 658 nm laser at 125 mA and 50 seconds of exposure. The bump around 920 nm is the observed PL.

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