Examining Different Nanostructures Through Spectroscopy

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Background

Nanophotonics, one of the many branches of Nanoscience, is the study of the behavior of photons and their interactions at the nanometer scale (1 nm is a billionth of a meter or 1 x 10^{-9}). In Nanophotonics, photons are typically observed interacting with nanomaterial, photonic crystals, or other nanostructures. **Nanomaterials**, are nano-scale materials with unique physical, optical, and electrical properties.

Photonic crystals, are periodic nanostructures with various optical properties that can guide, capture, or otherwise manipulate photons.

Phosphorescence is a process in which energy release is slowed down. In phosphorescent materials absorbed energy is later slowly released as photons.

Spectrograph is a device which splits a beam of light into its various wavelengths. In our setup the Single Photon Counter and CCD camera are connected to a spectrograph which allows them to distinguish the separate wavelengths and collect data accordingly.

Focus of my Project

The aim of this research was to explore the extensive world of Nanophotonics and observe and compare the reflectance properties of various nanostructures via advanced spectroscopic techniques.

The study involved synthesized materials and naturally occurring materials. We examined and took spectrums from La_2O_2S:Eu (a synthesized Phosphor), Quantum Dots (fabricated Photonic crystals), and various Butterfly Wings. Quantum Dots emission at different Laser power

Setup

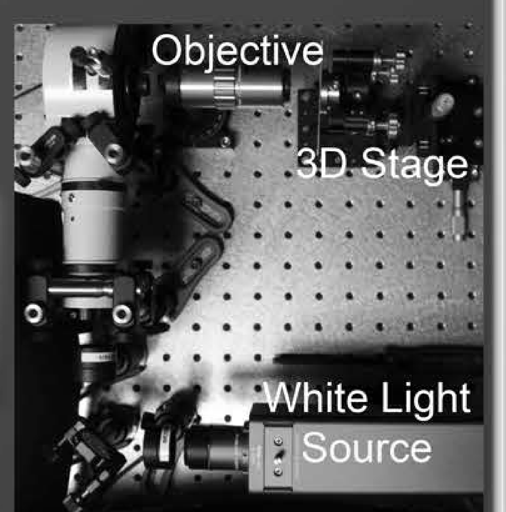
The setup comprised of 4 main elements:

Light Source:
White light bulb
Blue laser calibrated to 475 nm

→ 150x, 0.9 NA Objective Focuses Light Beam

→ 3D Stage for Chosen Sample

→ **Output:**
CCD Camera for Sample Viewing
Single Photon Counter for Measuring Decay Time
CCD Camera for Spectral Analysis



* Laser and Sensors are out of view

Background and Noise Filtering

When measuring data with the Spectrograph Background noise and CCD noise is expected. The noise was minimized using the following formula:

$$R = \frac{I_{wing} - I_{ccd\_dark}}{I_{bkgrd} - I_{ccd\_dark}}$$

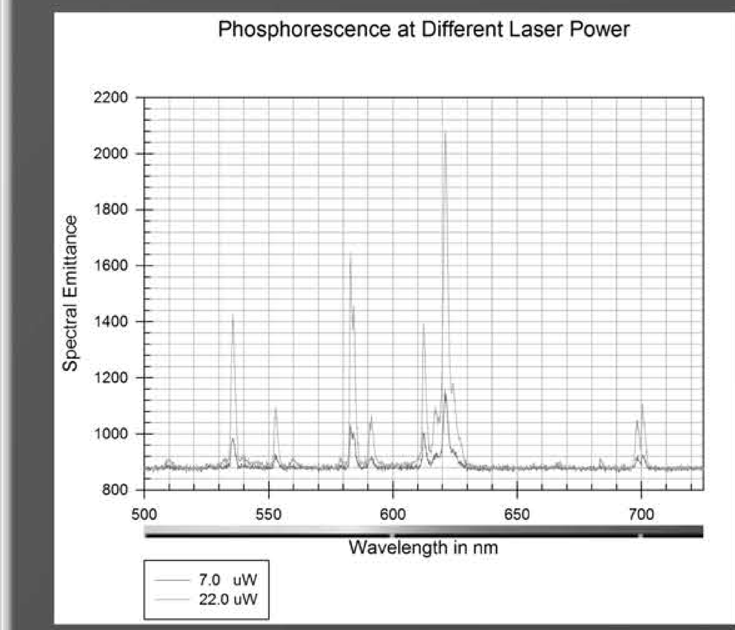
Where

I_{wing}- Intensity of light reflected from wing

I_{bkgrd}- Intensity of background light

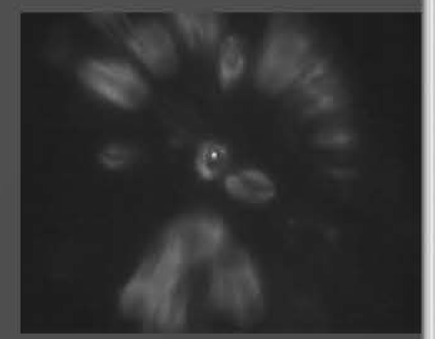
I_{ccd_dark}- Dark count from camera

Measurements

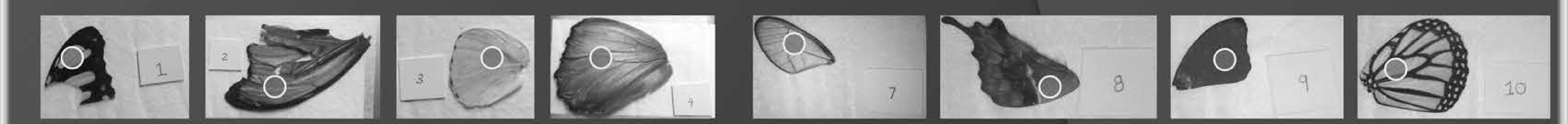


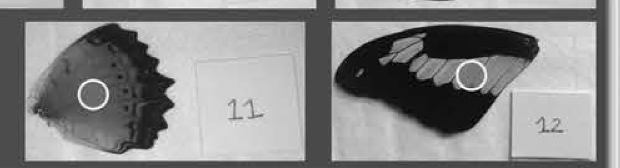
La2O2S:Eu Crystals

We measured a sample of La_2O_2S:Eu crystals under a 475 nm blue laser at different laser power. When exposed to energy La_2O_2S:Eu crystals are supposed phosphoresce a red color, which was confirmed by the spectrograph. And the emittance energy correlates with the amount of energy absorbed.

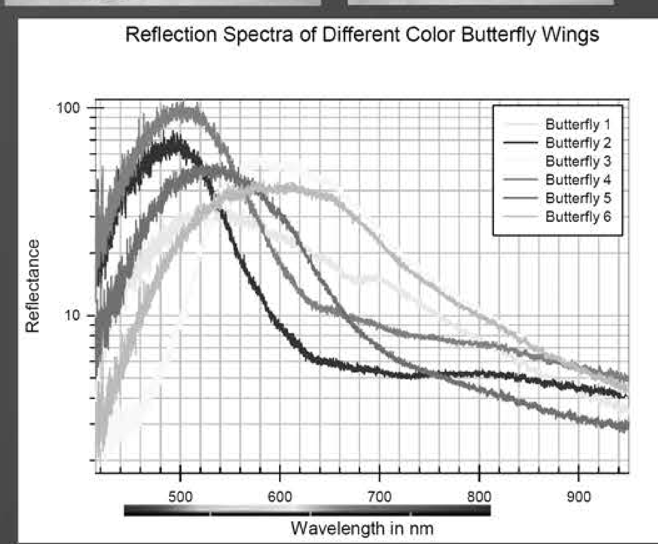


* La_2O_2S:Eu Crystals Glowing by Phosphorescence

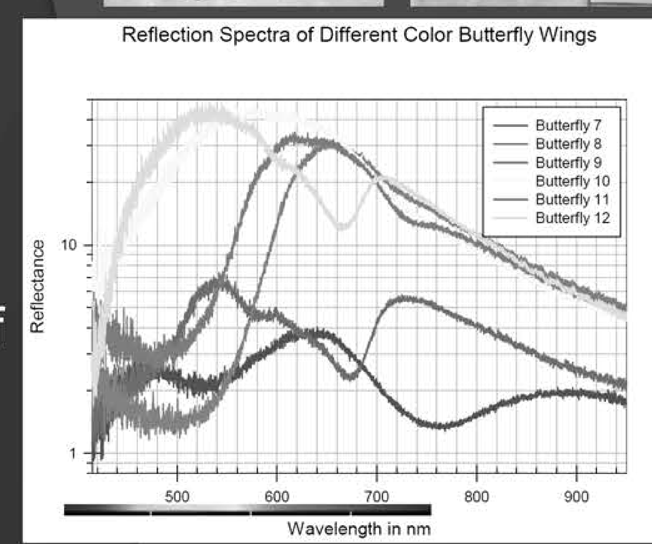




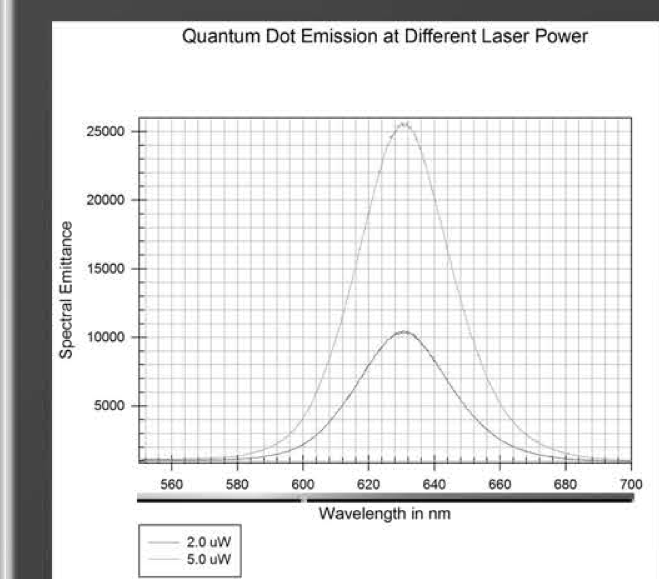
Butterfly Wings



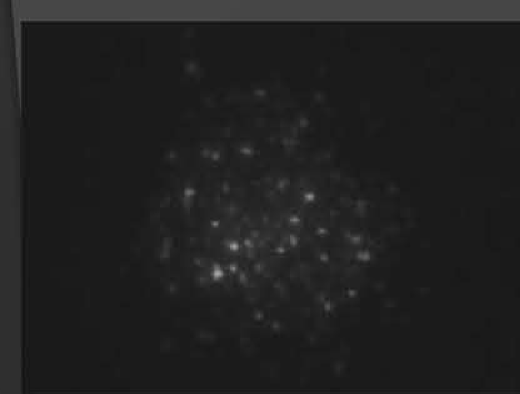
We also examined 12 different butterfly wings and took a spectrograph for each (where indicated by the circle). Butterfly wings of similar color created similar peaks when graphed.



Quantum Dots



Additionally we examined Quantum Dots which are miniscule Photonic Crystals that reflect a certain wavelength (in this case about 630 nm) because the Crystal's period matches up with the wavelength of the Laser beam and thus blocking the beam and reflecting it. And the emittance energy correlates with the amount of energy absorbed.



* Quantum Dots Emitting red photons as a result of their Photonic Crystal lattice

Conclusion and Future Work

Throughout the research various nanomaterials were investigated and the science behind photonic crystals was explored. It was found that the structure of butterfly wing scales had photonic crystal properties similar to the properties of synthesized photonic crystals, and could possibly manipulate other photonic crystals when placed together. Even though the different nanomaterials have different composition some were able to achieve similar results and matching histograms (as demonstrated by the histogram of Butterfly wing 9 and that of the Quantum Dots).

A better understanding of Photonic Crystals and Further examination of natural and synthesized Nanostructures could lead to more efficient and effective fabrication of Nanostructures and greater control over their various properties.

Cost effective and efficient fabrication of Nanostructures would allow for them to be applied in commercial technology to help with cleaner data transfer, more efficient solar panels, and higher quality display screens.

Acknowledgments

My mentor, Dr. Thang Hoang
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I would like to dedicate this poster to Parents, for supporting me on this great journey, And my sisters and cousins for driving me to the University and back whenever I needed a ride.