Hyperspectral Imaging of NIR-to-Visible Upconversion Luminescence of β-$NaYF_4$ Nanocrystals on Gold Microwell Arrays

Samantha Wang – Washington University in St. Louis

Aravind Baride, Md Yeathad Hossan, Dr. Mary Berry, Dr. Stanley May, USD Department of Chemistry

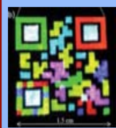
SPACT Center for Security Printing & Anti-Counterfeiting Technology

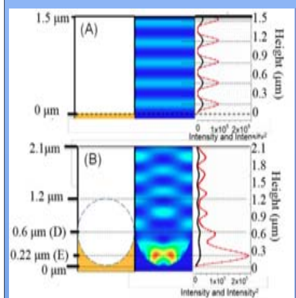
Washington University in St. Louis

UNIVERSITY OF SOUTH DAKOTA

Introduction

β-$NaYF_4$ upconverting nanocrystals (UCNC) absorb 980 nm NIR light and emit visible light. They have many applications in areas such as security printing, solar cell technology, and bio-imaging.





Finite Difference Time Domain Simulation of:
A) A flat gold surface
B) A gold microwell

However, they have low upconversion (UC) efficiency under low-power excitation, and show surface quenching effects that decrease luminescence intensity. Plasmonic surfaces can enhance UC luminescence by concentrating the electromagnetic field in the vicinity of the UCNC, while the surface quenching effects can be mitigated by adding a shell of undoped $NaYF_4$.

Objective

This study will compare UC luminescence of individual core and core/shell UCNC on and off gold microwell arrays under varying levels of excitation power using Hyperspectral Imaging.

Experimental

Synthesize Core and Core/Shell UCNC

- Synthesize β-$NaYF_4$: 25% Yb^{3+}, 0.3% Er^{3+}
- Synthesize large batch of core and core/shell β-$NaYF_4$: 17% Yb^{3+}, 3% Er^{3+} using real-time monitoring

Prepare Gold Microwell Arrays (GMA)

- Assemble monolayer of 1 µm latex spheres on clean gold slides; conduct electrodeposition to create a GMA

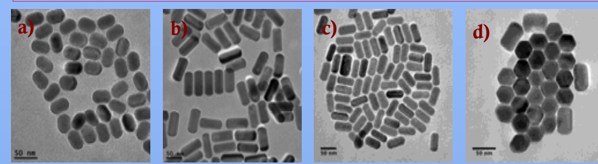
Hyperspectral Imaging (HSI) of UCNC

- Determine resolving power and sensitivity of Cytoviva Hyperspectral Microscope using 500 nm-sized UCNC
- Use HSI to collect UC luminescence spectra and blackbody scattering of individual UCNC
- Determine Instrument Response Function of Hyperspectral Microscope.

Results: Core and Core/Shell UCNC Synthesis

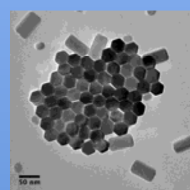
Core β-$NaYF_4$: 17% Yb^{3+}, 3% Er^{3+} GRNC

✧ These UCNC emit light at 540 nm (green) and 660 nm (red)



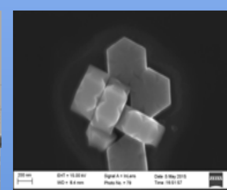
	a) May 28	b) June 2	c) June 15	d) June 26
Length	42.6 nm ± 1.3 nm	73.7 nm ± 2.0 nm	56.6 nm ± 1.7 nm	58.4 nm ± 1.1 nm
Width	29.8 nm ± 1.4 nm	31.9 nm ± 2.3 nm	26.8 nm ± 1.3 nm	37.7 nm ± 2.0 nm

Core/Shell GRNC



64.4 nm ± 2.0 nm x 33.6 nm ± 2.1 nm

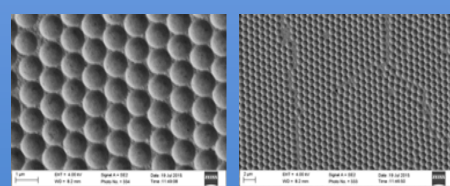
Core β-$NaYF_4$: 25% Yb^{3+}, 0.3% Tm^{3+} BLNC



512 nm ± 32 nm x 293 nm ± 11 nm

✧ BLNC emit light at 450 nm, 480 nm, 650 nm and 800 nm

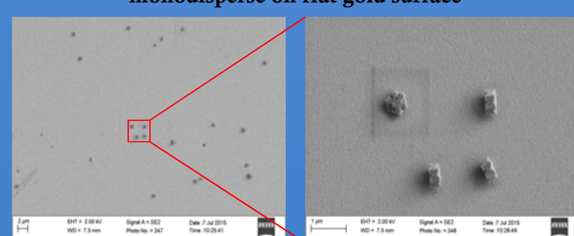
Results: Gold Microwell Arrays



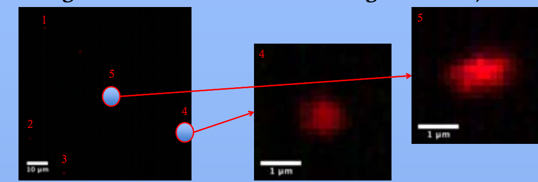
✧ Diameter: 1 µm
✧ Depth: 0.5 µm

Results: Hyperspectral Imaging

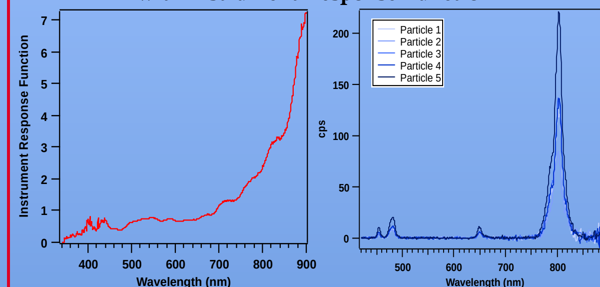
Step 1: Use SEM to determine that BLNC sample is monodisperse on flat gold surface



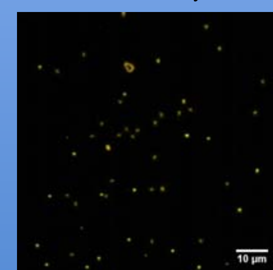
Step 2: Take high resolution dark field transmission (DFT) images of BLNC luminescence on glass slides, 100X

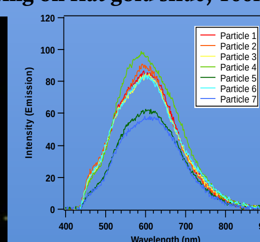


Step 3: Collect spectra for individual particles and correct with Instrument Response Function



Step 4: Take HR dark field reflectance (DFR) image of BLNC blackbody scattering on flat gold slide, 100X





✧ Uncorrected spectra

Conclusion and Future Work

Hyperspectral Imaging was used to collect UC luminescence spectra for single nanoparticles via DFT illumination, and blackbody scattering was collected via DFR illumination. Future work involves obtaining UC luminescence spectra of GRNC/BLNC via DFR on both a flat gold surface and a GMA. Comparisons of luminescence intensity on both surfaces will be made at varying excitation power densities.

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