Development of Nanophosphor Films for use in Thermometry of Nanoscale Thermoplasmonic Antennae

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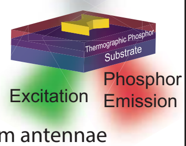
Introduction

This research aims to develop a new technique to measure the local temperature of nanoscale antennae using a film of phosphor nanoparticles

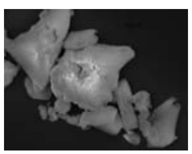


Phosphors have a temperature dependent photoluminescence lifetime
- > A nanoparticle film allows for maximum antennae coverage and detection
- > Removes previous limitations on device design and allowable substrates

Nanoantennae are thermoplasmonic devices that act as a nanoscale heat source
- > Have a variety of applications in optics, semiconductors, and drug delivery
- > An improved thermometry technique enhances device characterization, optimization, and development

The proposed technique removes the limiting annealing step used in previous methods

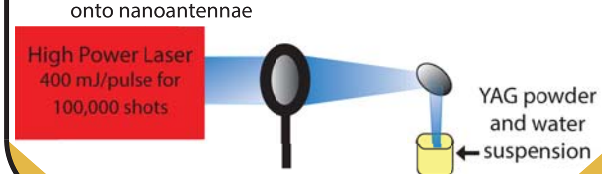
Experimental



Created YAG:Ce phosphor through combustion synthesis
- > Produced micron-sized particles with irregular shapes

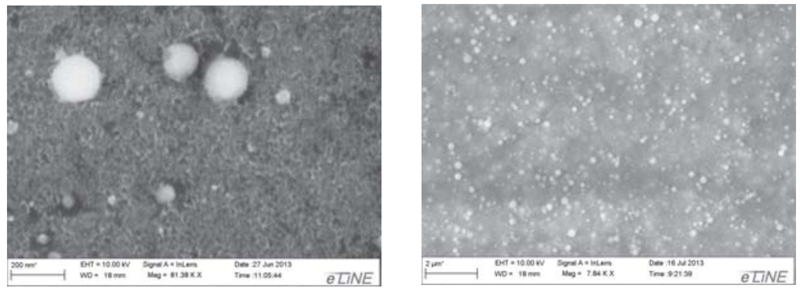
Creation of nanoparticles by suspending YAG powder in water followed by ablation with high power laser

Creation of film by drop casting onto silicon substrate
- > Same method will be used to deposit nanophosphor film onto nanoantennae



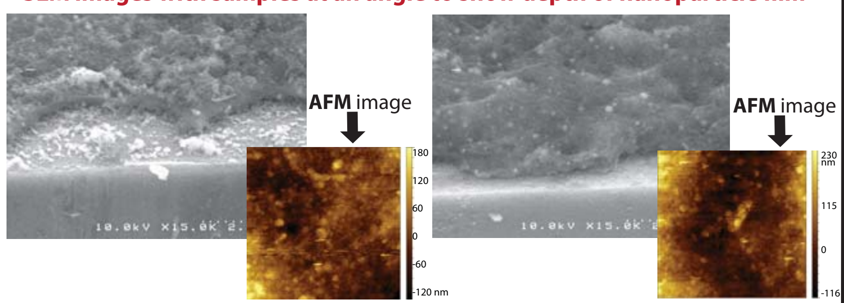
Characterization of Nanoparticles and Film

SEM images of YAG:Ce nanoparticles



Nanoparticles have an average size of 100-200 nm and a consistent spherical shape

SEM images with samples at an angle to show depth of nanoparticle film



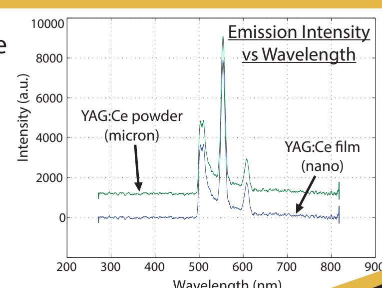
Film created by evaporation onto silicon substrate. Film is approximately 500-700 nm thick.

Photoluminescence

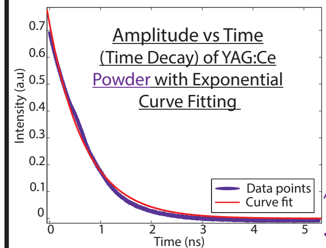
> Examining the photoluminescence of the nanoparticle phosphor film verifies the presence of YAG:Ce

> Peaks at wavelengths of 510, 554, and 610 nm

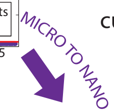
> Sufficient depth and density of particles in film to begin characterization



Determining Lifetime

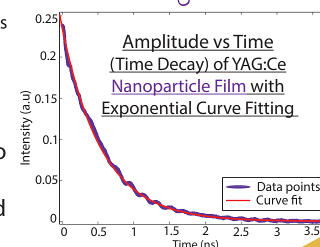


Lifetime of the phosphor is determined from the equation of the exponential curve fit



From curves
- > Lifetime of powder 81 ns
- > Lifetime of film 55 ns

When YAG:Ce particles changed from micron-sized to nano-sized, the lifetime was reduced



Conclusion & Future Work

We have successfully developed a nanophosphor film and determined the lifetime of the nanophosphor film. Future work will involve further characterization of the film, such as determining the lifetime at different temperatures. Ultimately, the film will be distributed on nanoantennae to determine the local temperature. Completion of this research will improve thermometry of nanoscale thermoplasmonic antennae and remove limitations on design parameters.

Acknowledgments

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