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Center for Nano Science and Technology

ND*nano* Summer Undergraduate Research
2017 Project Summary

1. Student name & university: Bryce Beddard. Vanderbilt University.

2. ND faculty name & department:
Dr. Anthony Hoffman – Department of Electrical Engineering
Dr. Ryan Roeder – Department of Aerospace and Mechanical Engineering

3. Project title: Monolayer thin film deposition of nanoparticles for analysis of optical properties

4. Briefly describe new skills you acquired during your summer research:

- Nanofabrication using techniques such as Electron Beam Evaporation and Plasma Cleaning
- Designing a protocol and continuing work to increase reliability
- Understanding of physical and chemical interactions in the nanoscale

5. Briefly share a practical application/end use of your research:
Using my research, the phononic optical properties of nanoparticles can be characterized. This characterization can lead to imaging, analysis, and potentially even treatment when combined with lasers in the mid- to far-IR spectrum.

6. 50- to 75-word abstract of your project:
Optical characterization of phononic nanoparticles is necessary to explore their potential applications in the mid- to far-IR spectrums. A robust dip coating process to develop monolayer thin films was designed. Various parameters were explored to increase the reliability and consistency of the process. These included adsorbed self assembled monolayers on the substrate, concentration of nanoparticles in suspension, and the volume of suspension used in each dip coat.

7. References for papers, posters, or presentations of your research:

Pauly, M., Pichon, B.P., Albouy, P., Fleutot, S., Leuvrey, C., Trassin, M., Gallani, J., & Begin-Colin, S. (2011). Monolayer and multilayer assemblies of spherically and cubic-shaped iron oxide nanoparticles. *Journal of Materials Chemistry, 21,* 16018-16027. doi: 10.1039/c1jm12012c

Wang, Y., Chen, L., Yang, H., Guo, Q., Zhou, W., & Tau, M. (2010). Large-area self assembled monolayers of silica microspheres formed by dip coating. *Materials Science-Poland, 28,* 467-477. Retrieved from www.dtic.mil/get-tr-doc/pdf?AD=ADA526674

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One-page project summary that describes problem, project goal and your activities / results:

Plasmonic nanoparticles have enabled new technological capabilities in sensing, imaging, and catalysis in the UV to near-IR spectrum. Phononic nanoparticles have potential for advancing similar capabilities in the mid- and far-IR spectrums. However, the optical properties of phononic nanoparticles are not well understood or characterized. Therefore, the objective of this project was to develop a robust process to deposit monolayer thin films of phononic nanoparticles for optical characterization. Gold-coated substrates were dip-coated in Langmuir-Blodgett bilayers comprising of a suspension of titania nanoparticles in acetone on top of an aqueous sublayer. Substrates were pulled through the bilayer at a controlled rate to allow self-assembly of nanoparticles into a thin film. Titania nanoparticles were coated in less than a monolayer of oleic acid to create amphiphilic nanoparticles and aid dispersion in acetone. Self-assembled monolayers with either -COOH or -OH ligands were also added to the gold substrate surfaces to aid nanoparticle adsorption. The effects of the type of self-assembled monolayer, concentration of nanoparticles, and the volume of the nanoparticle suspension on the quality of the deposited thin film was evaluated.

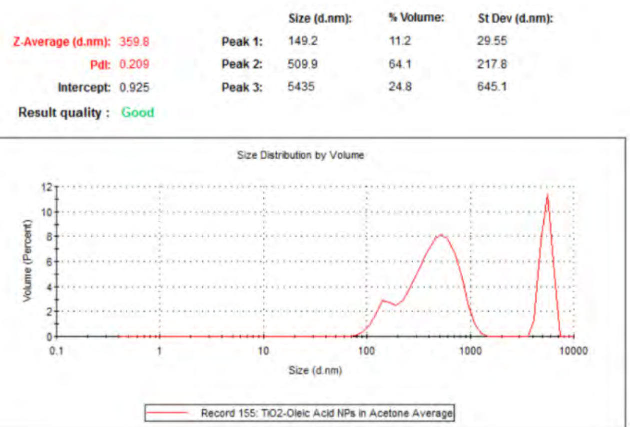

Figure 1: DLS of Acetone Suspension

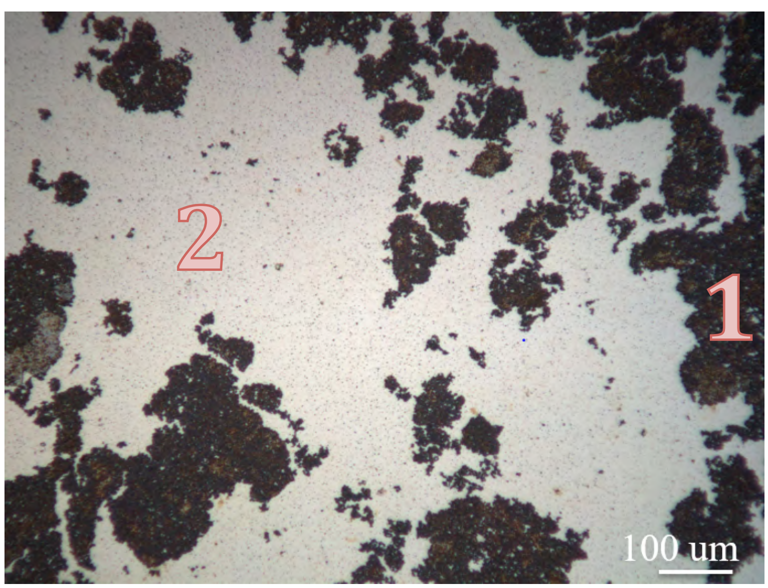

Figure 2: 200x Optical Microscope Image of Substrate

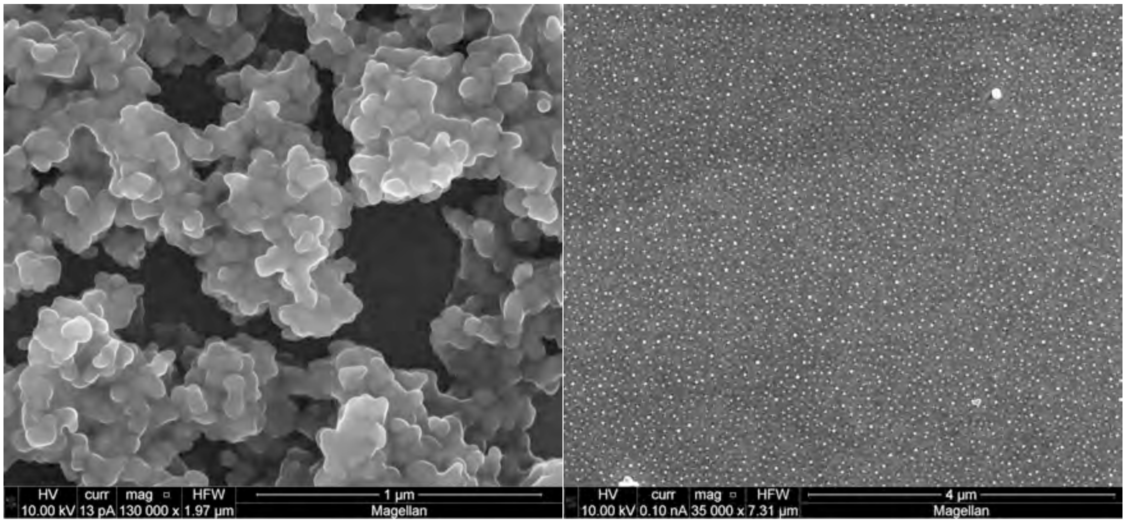

Figure 3: SEM of aggregated, multilayer region (1) and SEM of monolayer region (2)