Perovskite Nano-Structure Synthesis, Characterization and Application Photoluminescence Sensor Development

Abbas Idris[1,2,3], Shaocong Huo[1,2], Qimin Quan[1,2,]
[1] Harvard University School of Engineering and Applied Science, [2] The Rowland Institute at Harvard, [3] George Mason University

The Quantum Dot

Introduction

Perovskite quantum dot structures exude luminescence when excited by laser light and also under ultraviolet radiation.
Organometalic Halide perovskite particles have various properties that allow them to be great sensors for detecting nanoscale molecular interactions.
Perovskites absorb energy of various wavelengths as electrons are excited. When the electrons release some of this absorbed energy and return back to their ground state, the energy is emitted as colorful luminescence. Molecules that react with perovskites serve to change the luminescent properties of perovskites, either limiting it or enhancing it.

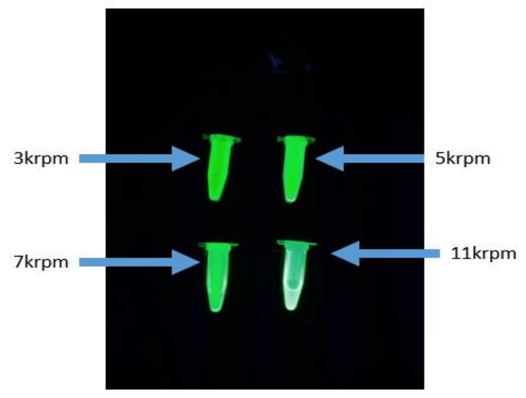
Objectives

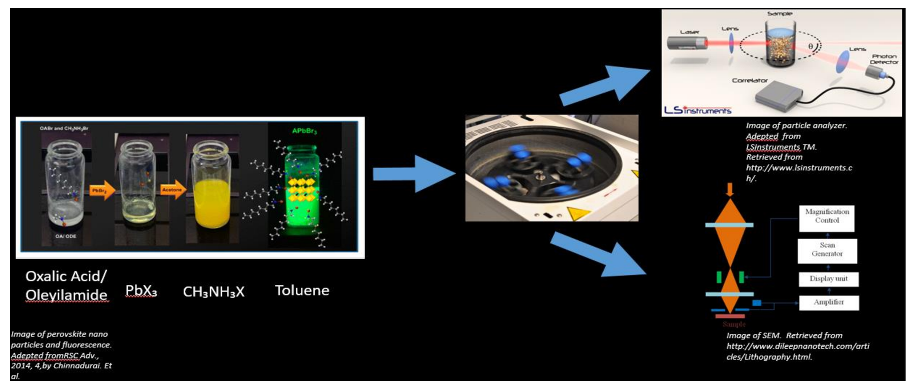
Perovskite quantum dot structures serve to increase the surface area to volume ratio which aids in optimizing the charge transfer mechanisms that occur during contact with other particles. Using these ideas to our advantage, we hope to create an entire class of perovskite quantum dot based sensors to aid in molecular differentiation at the nanoscale level.

Synthesis of Perovskite Quantum Dots

Perovskite Synthesis with Demulsifier

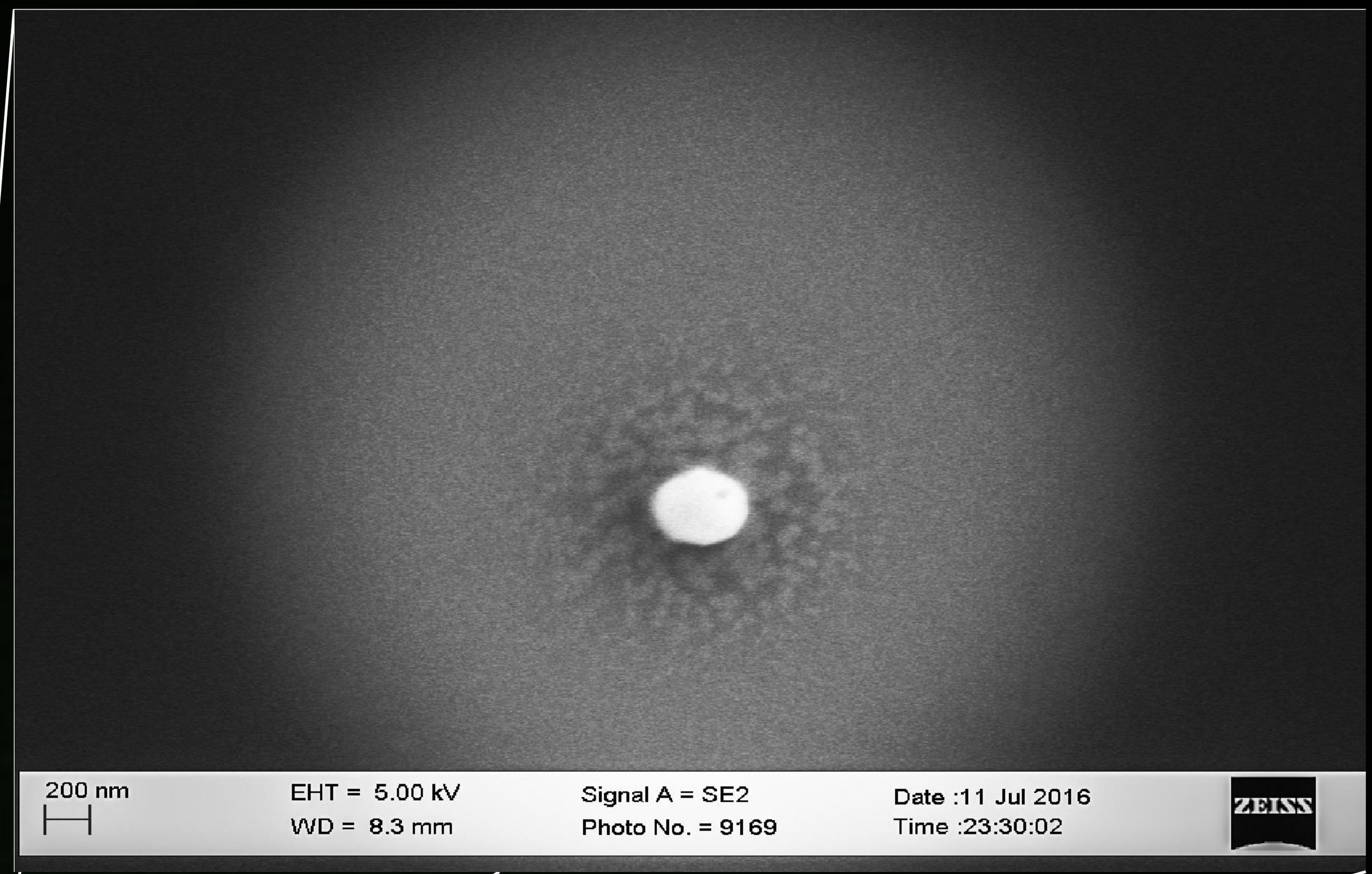
1. 1mL of DMF is placed into vials of 0.2 mmol of $PbBr_2$ and 0.16 mmol of MABr
2. 20 µL is also placed into a flask with oleic acid and 10 mL of Hexane
3. contents of the MABr and $PbBr_2$ vials are then added to the flask after being vortexed
4. split the 10mL solution into four vials of 2.5 mL precursor. To these vials we add 0.4mL of tert butanol

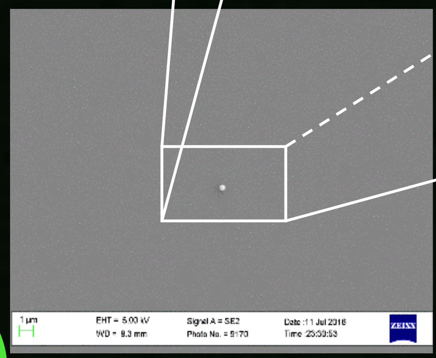




Temperature Dependent Perovskite Synthesis

1. 0.4 mmol $PbBr_2$ and 0.32 mmol MABr are placed into a 10 mL DMF solution with 0.1 mL oleylamine and 1mL oleic acid
2. 5 mL of toluene is then preheated within the range of 0 to 60 ^{0}C and 0.5 mL of precursor is injected into the toluene under a vortex.
3. Centrifuge as a means of removing unwanted large particles from solution



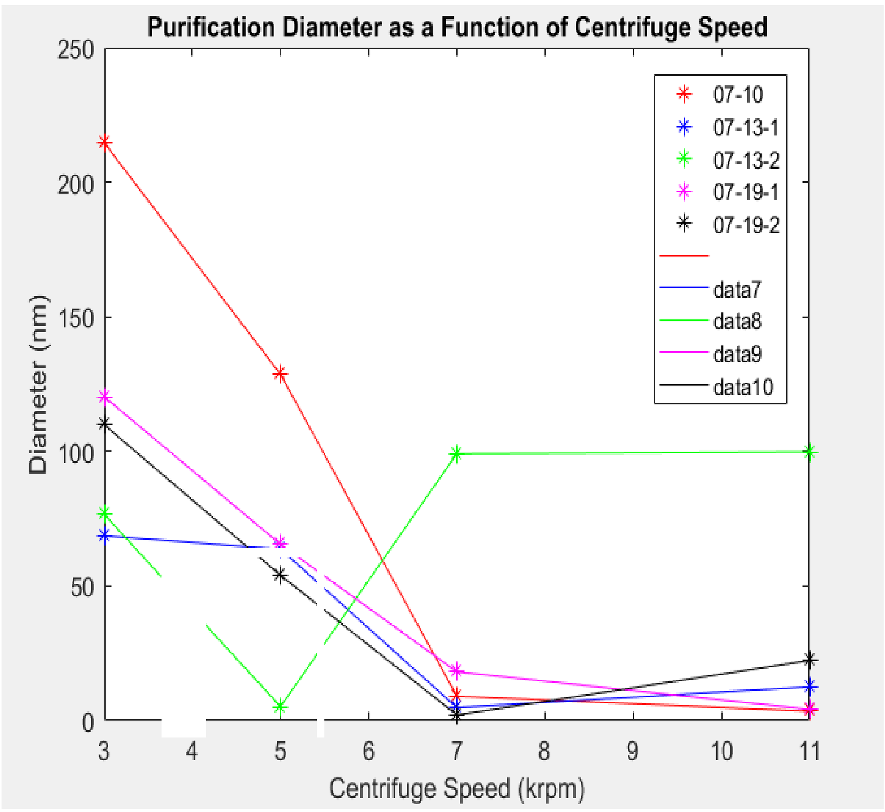


Imaging and Particle Analysis

We use the Delsa Particle Size analyzer which gives us volume, intensity, diameter and number distributions of particles in our solution.
PLQE measurements are conducted with high powered lasers to attain emission spectra and detect the luminescence of perovskite nanoparticles with emission peaks covering the 475 to 520 nm range
High resolution microscopy, SEM, is used o ensure consistency in particle size using an SE2 detector

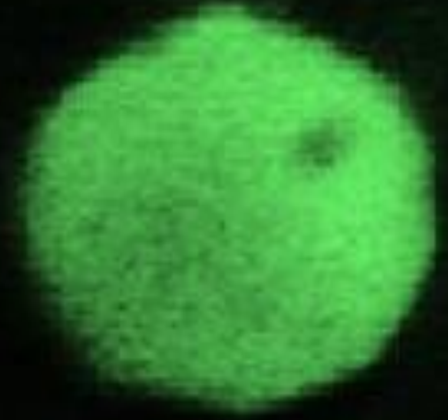
Results and Conclusion

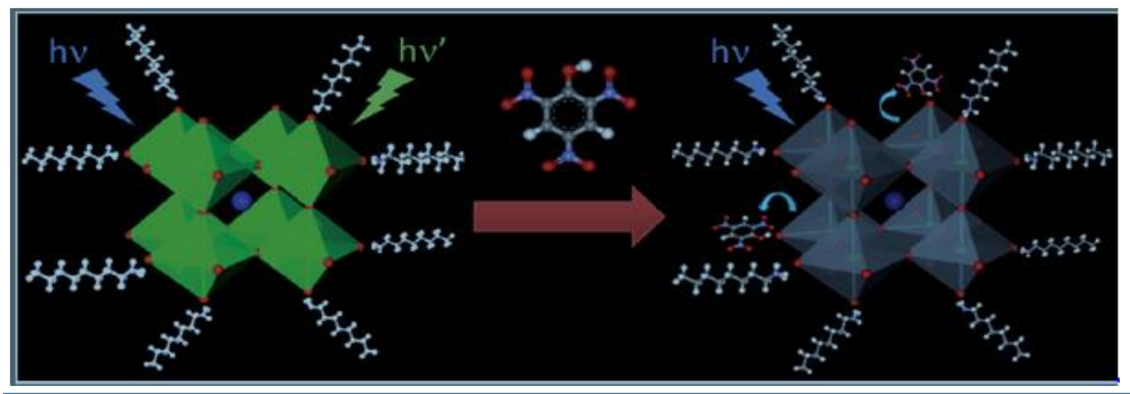
The three methods for perovskite synthesis have been tested. After multiple syntheses, the temperature dependent method appears to be the most stable method of synthesis. The remaining two methods are highly unstable and will decompose, when exposed to air, in a matter of a few days. The temperature dependent method maintains stability for many weeks before finally decom-posing. Perovskite nanoparticles of under 10 nm have already been found through this method of synthesis and a modified method using copolymers and an ligand system is already under development. The image shows an SEM image of temperature dependent synthesis, spin coated on a silicon wafer.



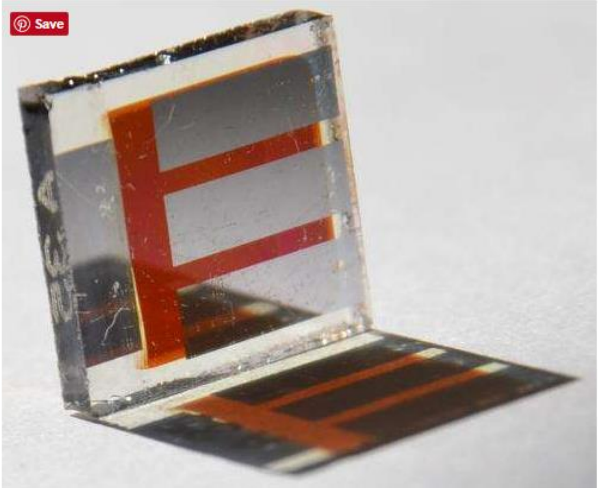
Sensor Development

Spin coating glass slides with quantum dot solution and exposing the solid state product to certain molecular structures causes a change in perovskite PL intensity. This may serve as an effective method for testing perovskite PL changes in the direction of sensor development.





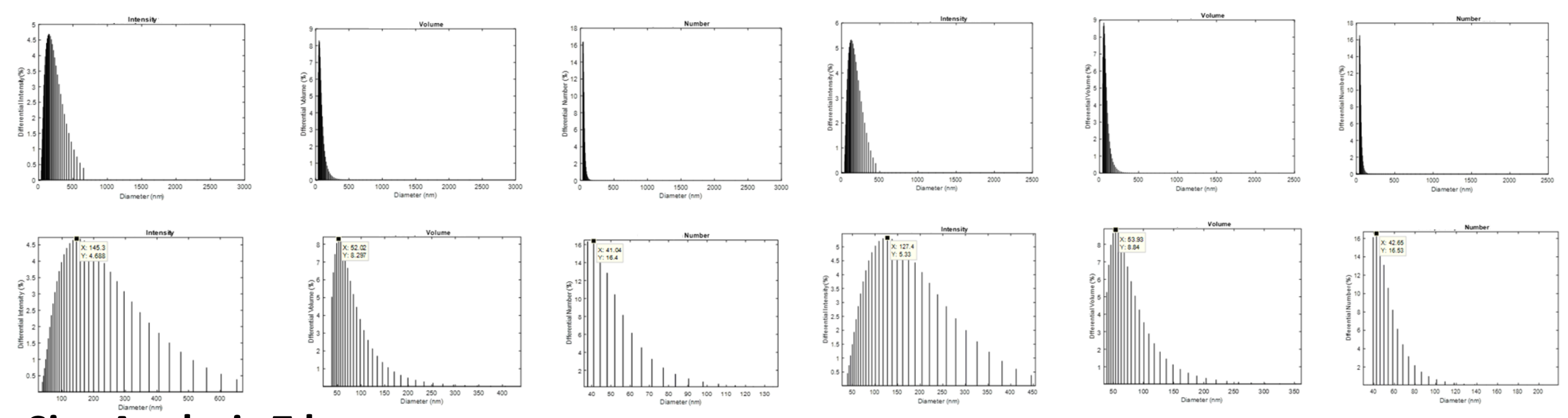
Images of perovskite nano particles and fluorescence. Adapted from J. Am. Chem. Soc., 2014, 136 (3), pp 850–853, by Luciana C. Et al.



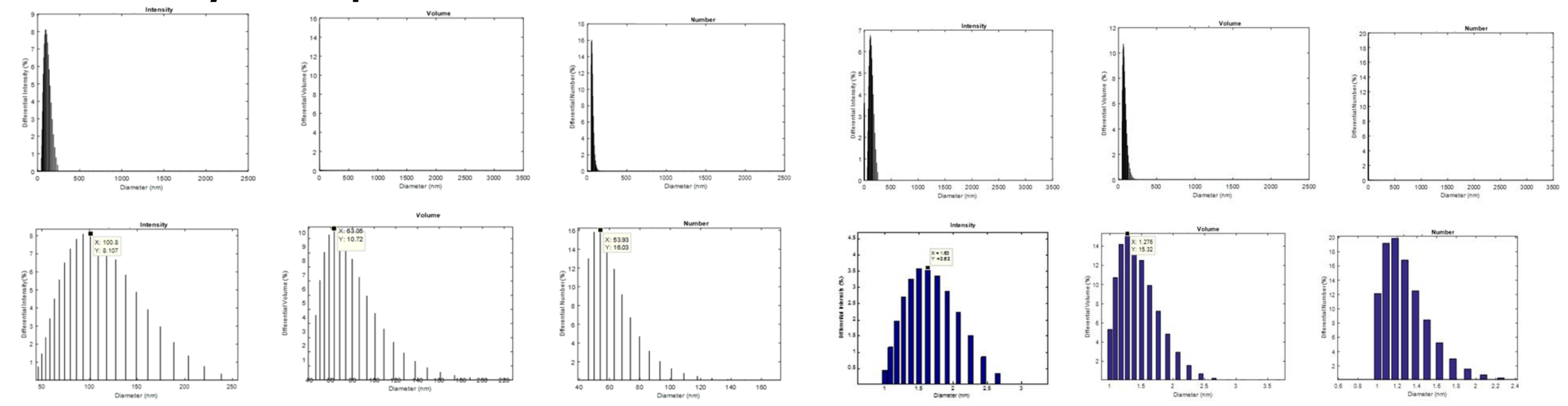
(image of thin film perovskite solar cell adapted from www.technology.org)

Data Acquisition and Characterization

Size Analysis 3 krpm



Size Analysis 7 krpm



Size Analysis 11 krpm