Spatially-Resolved Electroluminescence of Individual Au Nanoparticles

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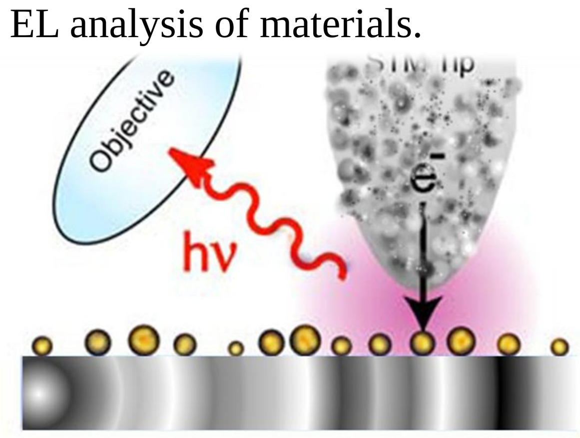
BACKGROUND

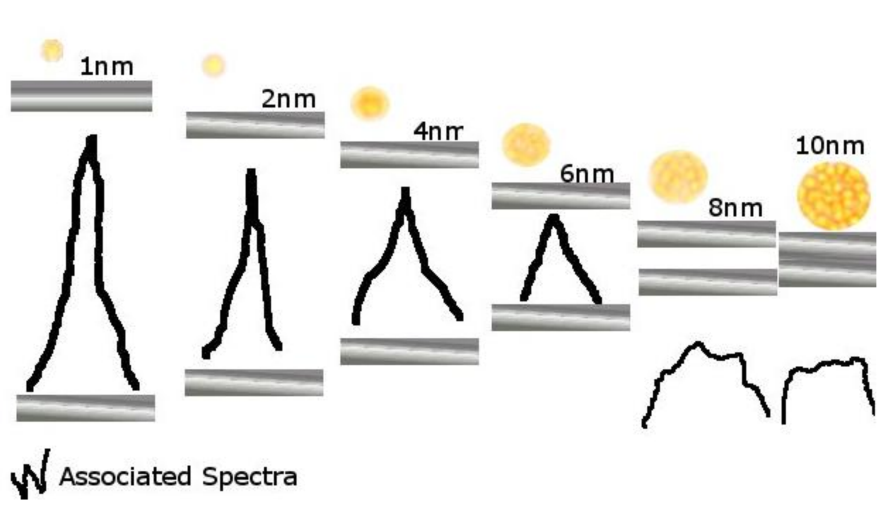
STM-EL: Scanning Tunneling Microscope Electroluminescence
Is a novel method of examining the electroluminescent properties of materials with extreme precision. This technique allows for topographic and EL analysis of materials.



STM-EL uses STM's extreme spatial resolution to permit resolute EL probing of conductive materials. In this project gold nanoparticles are examined using STM-EL to try and determine EL properties and prove abilities of STM-EL.

Scheme of STM-EL

Photoluminescence techniques have increased far beyond current electroluminescence techniques, yet knowledge of materials' electroluminescent properties is integral to improving technologies such as LED and solar cells.



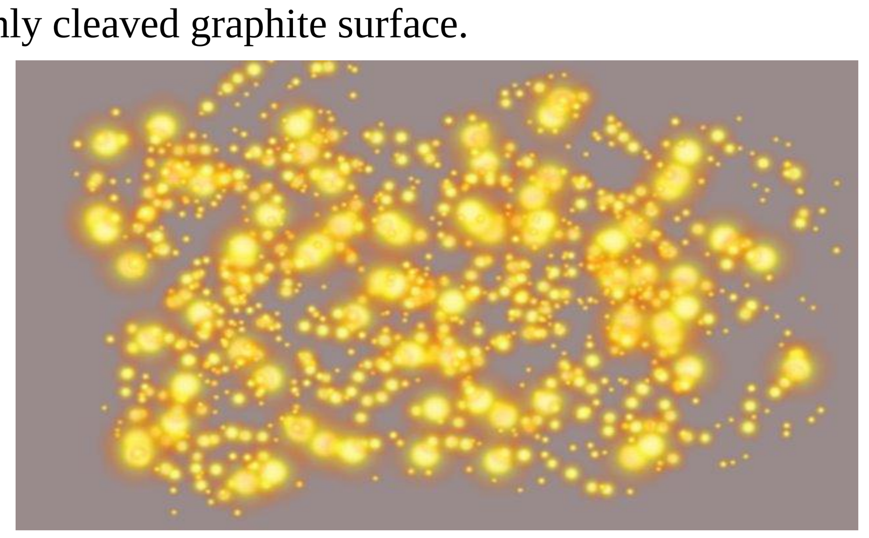
This shows the expected transition sizes as particles begin to exhibit plasmon resonance, and a broader spectra of emission.

Smaller particles have larger band gaps and individual peaks corresponding.

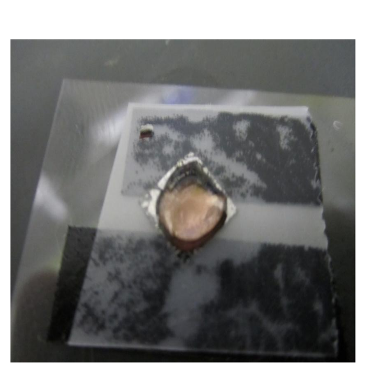
Using STM-EL we hope to determine this transition point.

MATERIALS AND METHODS

Via STM-EL Gold Nanoparticles were analyzed on a flat, conductive, freshly cleaved graphite surface.

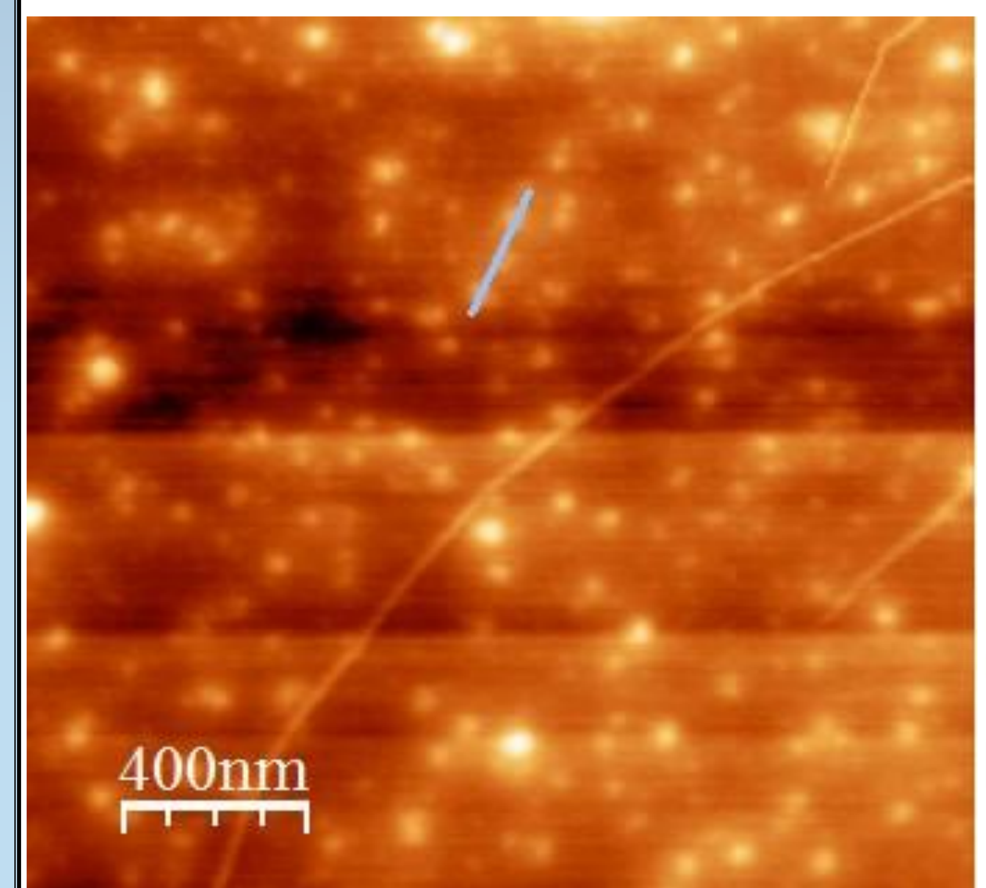


1. Optimal particle distribution was achieved by leaving colloid solution on for 75 seconds.
2. Sample was then dried using Nitrogen gas at low pressure.
3. Particle size and distribution confirmed via Atomic Force Microscopy

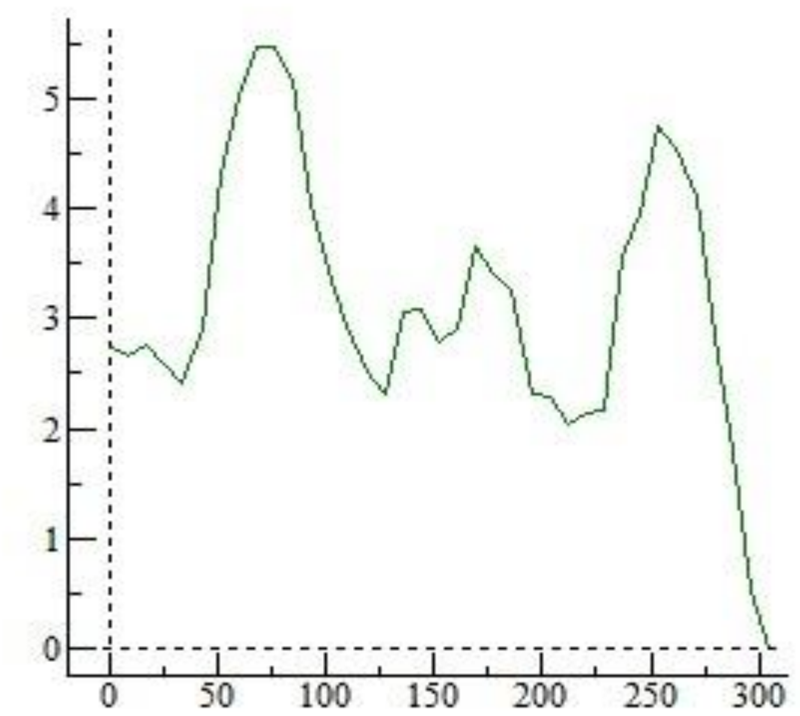


MATERIALS AND METHODS

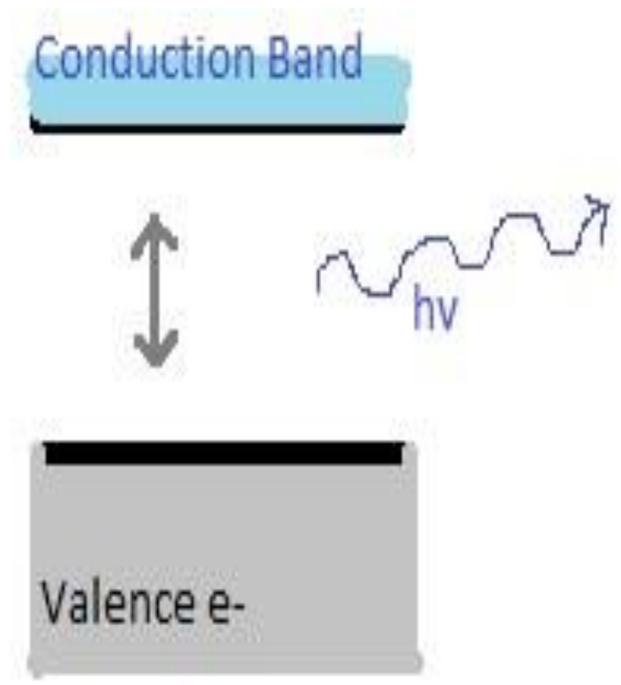
Particle size and distribution on surface is viewed via Atomic Force Microscope.

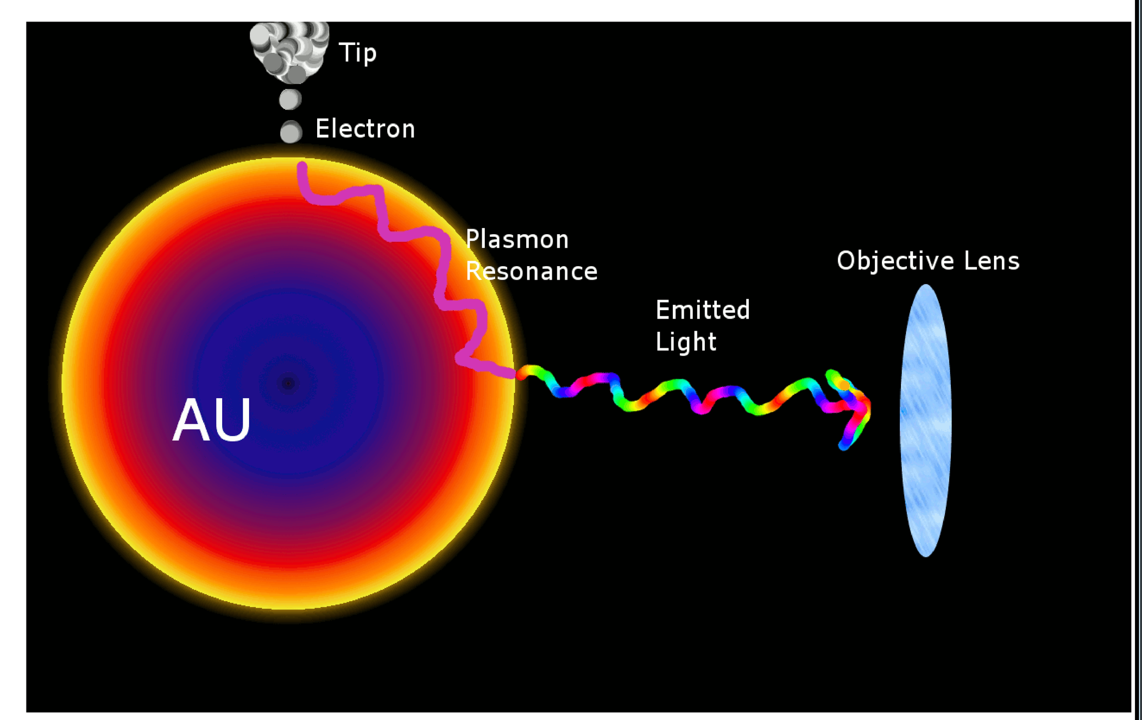


Size (nm) corresponding to particles crossed by line in picture of AFM scan.

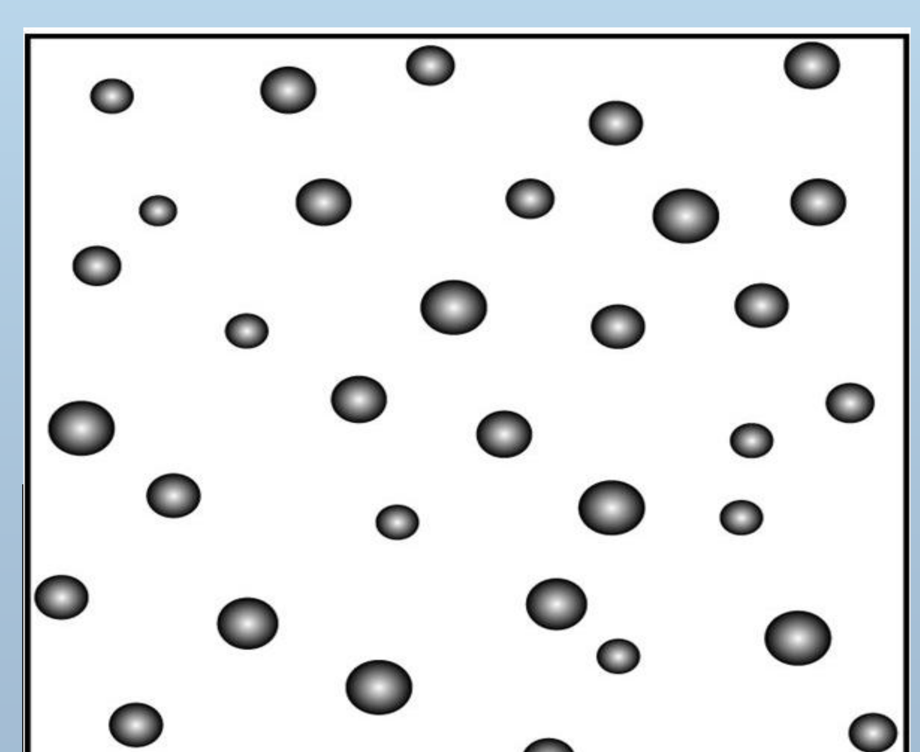


The sample can then be analyzed in the STM-EL. When an isolated particle is found, it can be pinpointed and targeted by the STM-EL probe and stimulated with a varying bias until the emission is observed. At some point between 5 and 10nm it is expected that the band gap will be too small to be observed and instead a broad spectrum indicative of Plasmon Resonance will be observed.

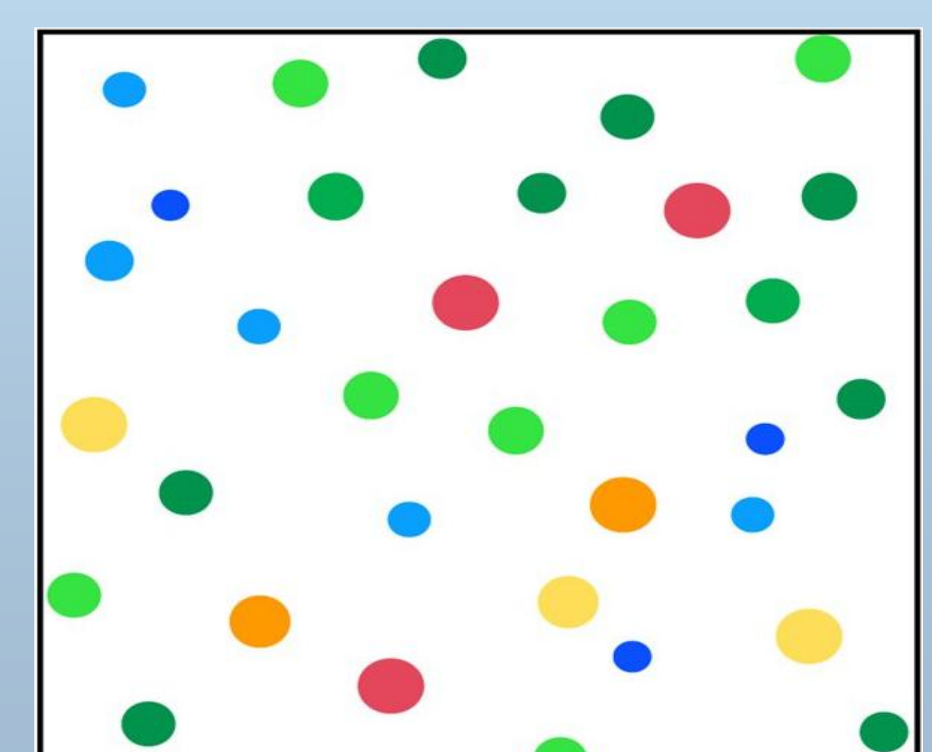




When these Electroluminescent properties are determined in the STM-El it will allow for the surface to be characterized in terms of both the topography and the respective light wavelengths emitted.



Topographic Image



EL Photon Image

RESULTS

This experiment involved extensive characterization of gold nanoparticles in the target range. The y were placed and studied upon both Mica and Graphite surfaces via Atomic Force Microscopy. The difficulties associated with attaching completely bare particles to a bare, flat surface led to a difficult characterization process. The deposited particles' distribution was unpredictable and difficult to control and it was difficult to prevent particle clumping. More experimentation should be done to find more efficient techniques for bare particle to bare surface attachment.

During the STM-EL analysis it also became apparent that the bias of the tip and sample can cause the unattached particles to drift or be pushed by the probe and thereby be difficult to isolate and scan. The STM-EL is still capable of this analysis though better ways must be found to attach and isolate the particles without compromising the structure, conductivity, or particle surface.

CONCLUSIONS

As Electroluminescent properties continue to be integral to the development of technologies including solar cells and LED it is important that this research be continued. As the problem for particle drift is addressed we will hopefully be able to analyze individual particles and learn more about the properties of nanomaterials. Currently PL technology is far more capable, but with the development of this STM-EL technique the gap will be closed. With STM-EL's ability to analyze materials on the angstrom scale we can hopefully greatly assist the fields of nanotechnology and improve technology such as LED and solar cells.

FUTURE WORK

In the future the project the project will be continued to pursue mapping of the quantum properties of gold nanoparticles <10nm. Different ways of isolating the nanoparticles for probing as well as different methods of distribution will be explored.

STM-EL is a difficult procedure in some ways, and hopefully via further use, the process will become more streamlined and easier to apply to new scenarios.

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