

Large Scale Nanofermentation of Quantum Dots

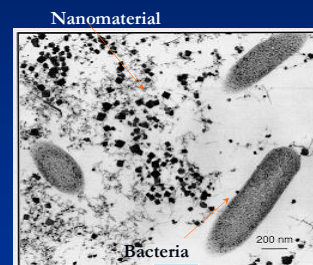
Lonnie Love, Tommy Phelps, Ji-Won Moon and Chad Duty
Oak Ridge National Laboratory

Background

Nanofermentation is a process that uses micron sized bacteria to facilitate the synthesis of a wide range of nanomaterials

Fundamental Advantage of Approach:

- **Very scalable**
 - 50,000 gal fermentor provides 500 kg/month
 - Equivalent to 10.8 MW of PV material /year
 - In-situ integration of synthesis and surfactant yields highly dispersed materials
- **Energy efficient**
 - Organometallic synthesis occurs at 500°-600° C (Roca et al., 2006)
 - Sol-gel requires 250° - 400° C annealing under vacuum (Xu et al, 2007)
 - Nanofermentation occurs between 10° and 60° C (Phelps et al., 1998)
- **Environmentally-friendly process**
 - Chemical approaches require environmentally unfriendly solvents to control size
 - Nanofermentation is a naturally occurring biological process.
 - Nature's been doing it for hundred of millions of years
 - We've just a) relocated where it's occurring and b) modified the parameters to control the product
- **Potential for very low cost**
 - Example: Size controlled magnetic materials
 - Chemical process: \$570 to \$1340/kg
 - Nanofermentation: \$60/kg



Bacteria discovered in oil and gas deposits in 1992

- **Bacteria was geologically isolated (> 1 km underground) for 100 to 140 million years**
 - Strains of thermophilic anaerobic bacteria produce extracellular particles of defined size (3 nm – 300 nm)
- **In 2006, ORNL discovered size and shape control**
 - Addition of specific control agents control size and shape of final material
 - R&D Magazine named one of the top 100 new technologies and top 25 nanotechnologies of 2006
 - Process is patented and bacteria available to public for licensing

Project Objective

The objective of this seedling project is to:

- **Explore nanofermentation of quantum dots**
 - Quantify material quality, define scaling laws, production rate and cost with focus on future photovoltaics and solid state lighting
- **Establish scaling laws for process**
 - Demonstrate efficiency from mL to L samples (target 3 g/L/month)
- **Estimate potential energy impact (Quads/year) and cost**
 - Target < \$1/Watt for PV material

Project Status

First Quarter Accomplishments:

- Successful synthesis of mg samples of cadmium-sulfide (CdS), copper-indium-gallium-sulfide (CIGS_u) and CIGSe (selenide) materials.
 - CIGSe was a major breakthrough, key component for future PV applications

Patents

- ORNL Patent Disclosure, S-111,586, "Fermentive method for making non-oxide fluorescent nanoparticles"
- ORNL Patent Disclosure, SI 1686, "Microbial-mediated method for metal oxide nanoparticle formation"