

Utilizing Bacteria for Sustainable Manufacturing of Low-Cost Nanoparticles

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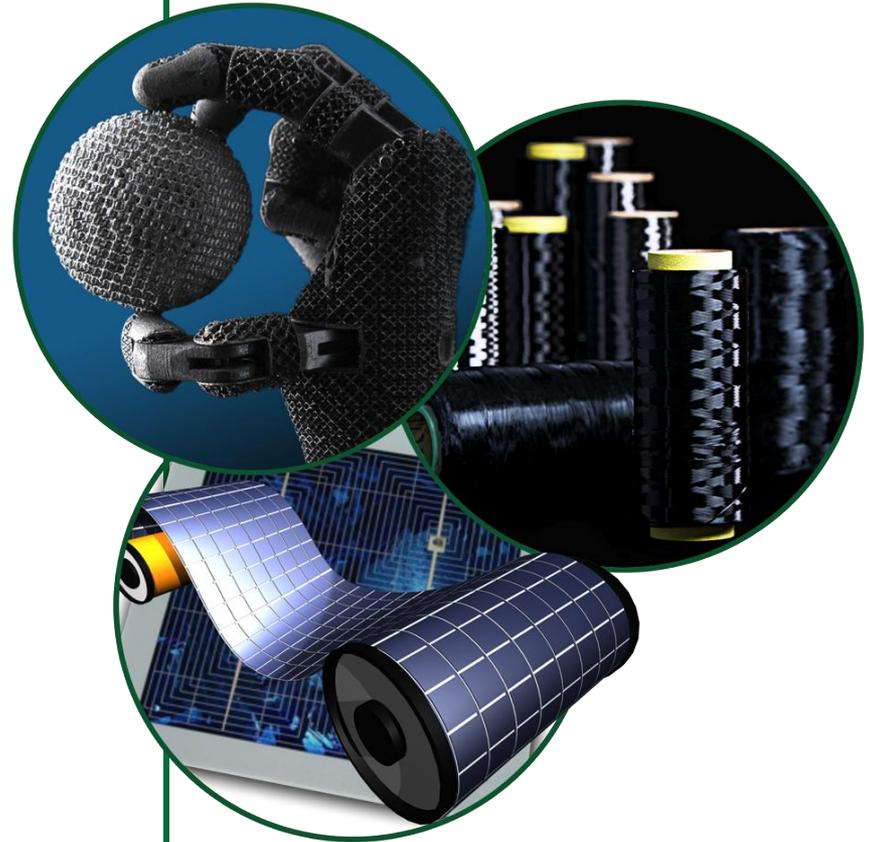
Technical Lead
Additive Manufacturing
Roll-to-Roll Processing

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Advanced Manufacturing Office



U.S. DEPARTMENT OF
ENERGY



 **OAK RIDGE NATIONAL LABORATORY**
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

NanoFermentation



NanoFermentation



Cheap oxidized bulk salts



Natural bacteria



Cheap sugar



CO₂



Magnetic



Valuable mass produced nanoparticles
Semiconducting



Phosphor



Photovoltaic



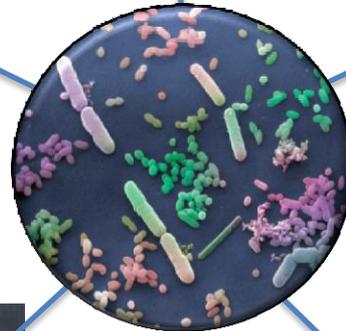
Platform Technology

Metal Oxides

Super Para Magnetics

Energy Storage

Ferro - fluids



Conventional Nanoparticle Synthesis

- **Milling & Grinding Rocks (impurities)**



Ore is **not** pure



High mechanical energy



Lots of waste



Harmful wastewater

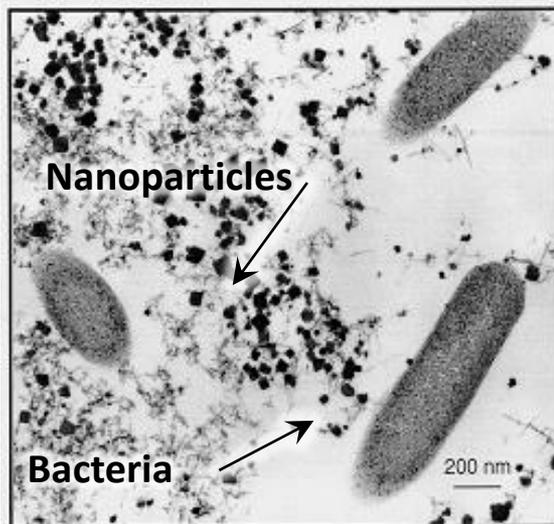
- **Chemical Synthesis (poorly scalable)**
- **Dilute Solutions (poor yield)**



Leads to extremely expensive nanoparticles (\$3k-10k per gram)

Technology Leadership

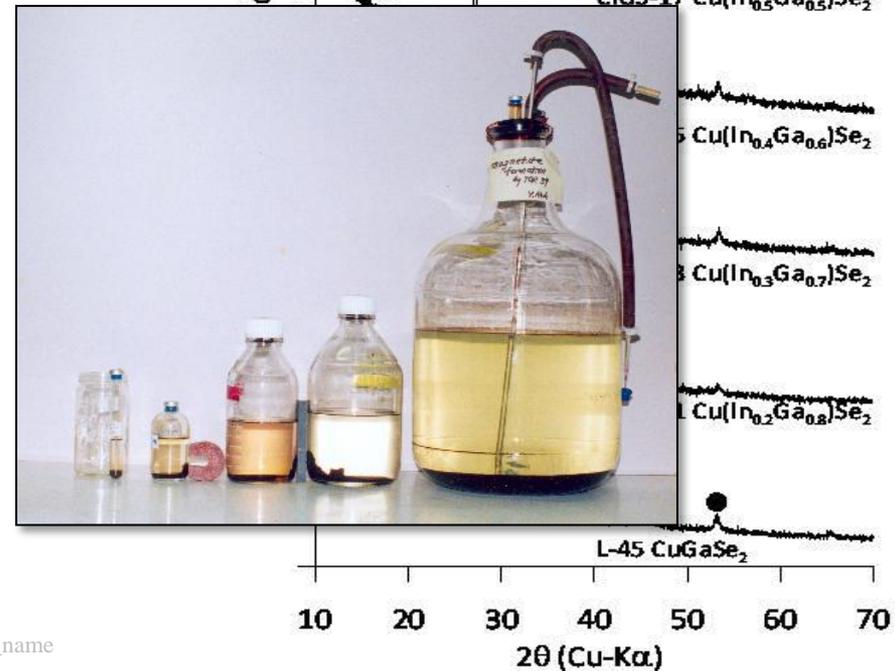
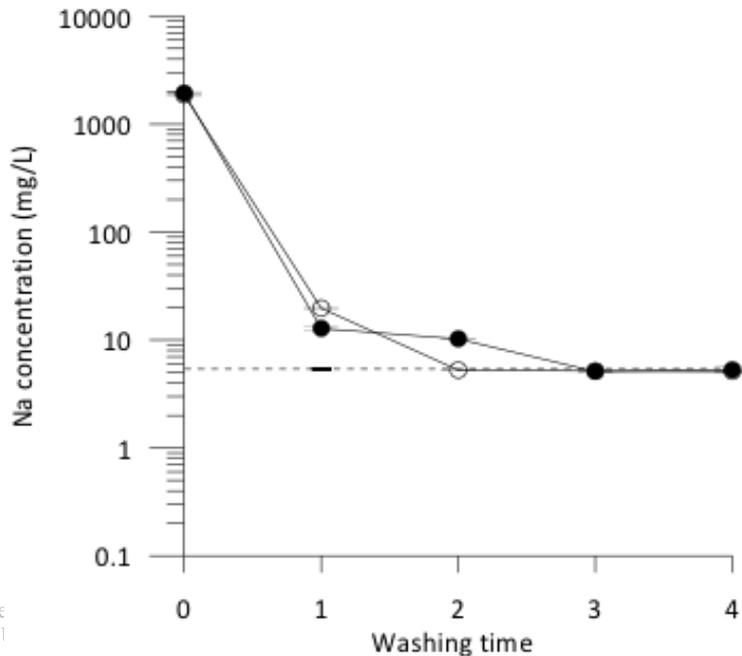
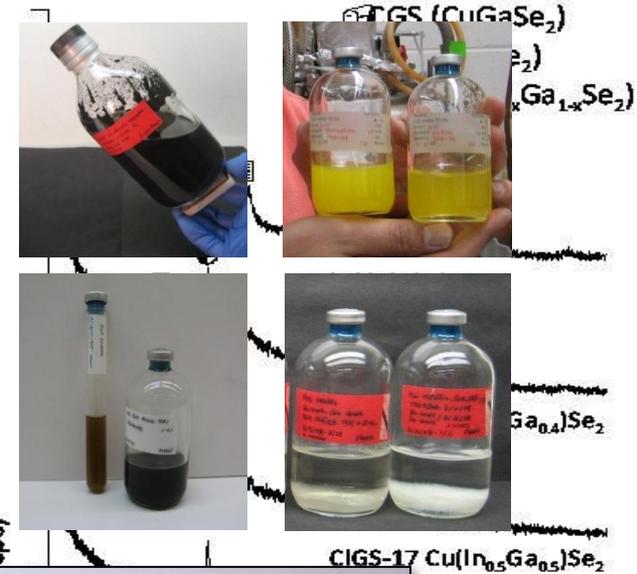
- By contrast, NanoFermentation is
 - Scalable: 500kg per month (50,000 gal. fermenting tank)
 - Energy efficient: occurs at 10° – 60° C
 - Environmentally friendly
 - Low cost (\$1-10 /g) **1,000x Reduction**



Demonstrated Proof-of-Principle

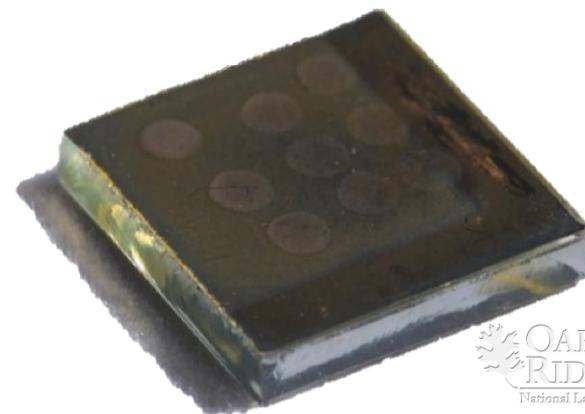
- NanoFermentation works

- Several materials synthesized
 - (ferrites, CIGS, CdS, CZTS)
- Controlled size, shape, composition,
- Clean
- Scales (10 mL → 30 L)



Long Term Research Needs

- **Synthesis of Nanoparticles**
 - What materials are possible?
 - Explore Eh / pH range
 - Focus on critical / expensive nps
- **Functionalization of Nanomaterials**
 - Development of inks / pastes
 - Dispersion of nanoparticles
- **Integration of Nanomaterials**
 - Functional devices / advanced materials
 - Performance enhancements



Thank You

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