Amastan Technologies

Department of Energy
Solid State Lighting Workshop
Nashville, TN

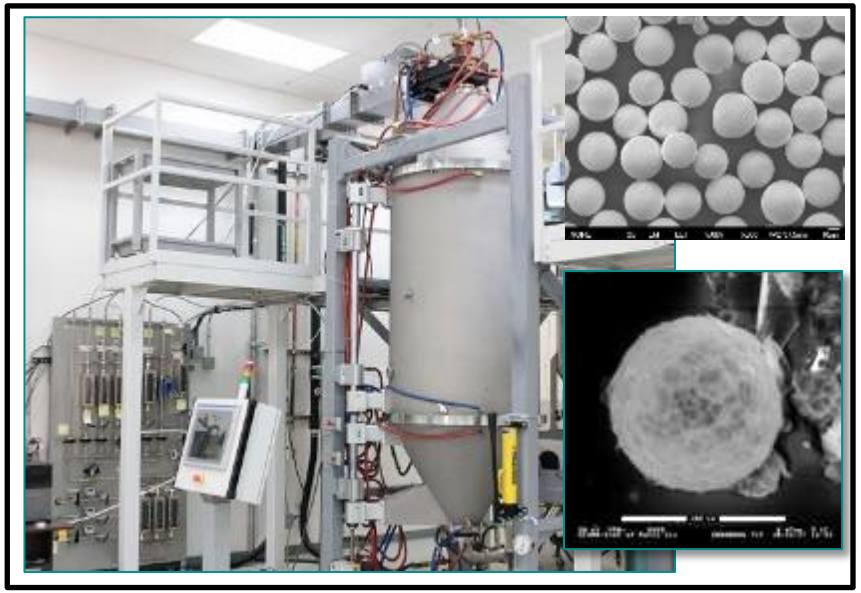
Kamal Hadidi
CTO
Amastan Technologies
25 Commerce Way
North Andover, MA 01845
khadidi@amastan.com
978 258 1645

AMASTAN
The sun is the limit

Proposed Agenda

1. Amastan's Technology Platform and Competitive Advantage
2. Major challenges in Common Processing Methods
3. UniMelt Applied to the Production of Phosphors
4. UniMelt Theorized Production of Quantum Dots

Amastan Technologies

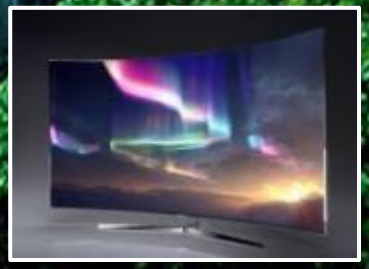


- Founded 2007, technology from MIT, UConn
- 20 employees
- 20,000 sq ft HQ in Boston, MA
- 11 patents with 15+ pending

- High temperature processing of borides, carbides, oxides, nitrides, metals & alloys
- Addressing $40B in materials markets
- 6 kW – 15 kW – 3 x 55 kW facilities: both powder production & coatings capable

Clean, Advanced Materials

AMASTAN produces materials for the next generation of clean technologies and high value industrial products



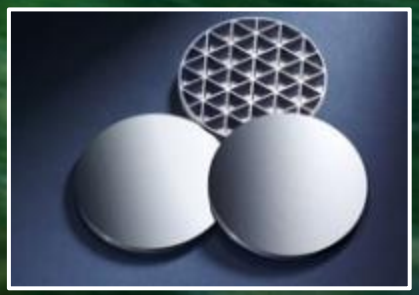
Advanced Displays

Industrial Coatings

Batteries & Grid Storage

Transparent Ceramic

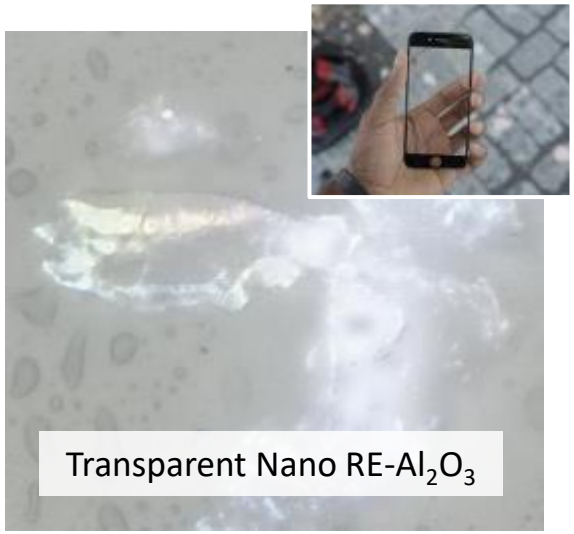
LEDs and lighting

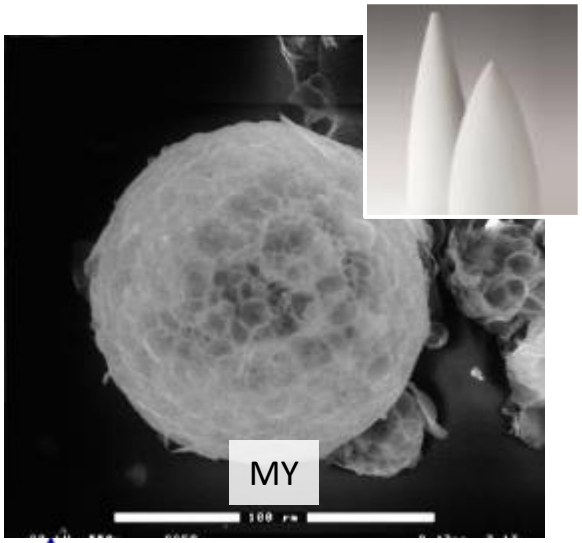


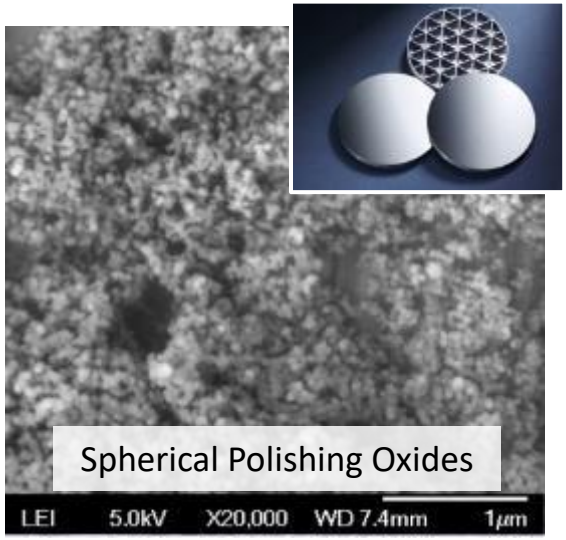
Semiconductor

3D Printing Metals

Amastan Materials Produced (sample)







Current Issues in Phosphor Production

- Solution Based Processes
  - Co-precipitation: material nucleated and grown in solution
    - Multi step batch process
    - Difficulty in scale-up
    - Prone to contamination
    - Liquid waste
  - Spray pyrolysis: Solution-precursor sprayed into furnace or non-microwave plasma
    - Multi-step process
    - Wide size distribution
    - Difficulty in achieving fully dense particles
    - Thermal non-uniformity

- Solid State Processes
  - Heterogeneous feedstock
  - Multi-step batch process
  - Production of material lasts hours to days
  - Thermal process non-uniformity
    - Particles in the center of crucible see less heat
  - Particle morphology dictated by crystal structure
  - Wide size distribution requires particles classification results in waste

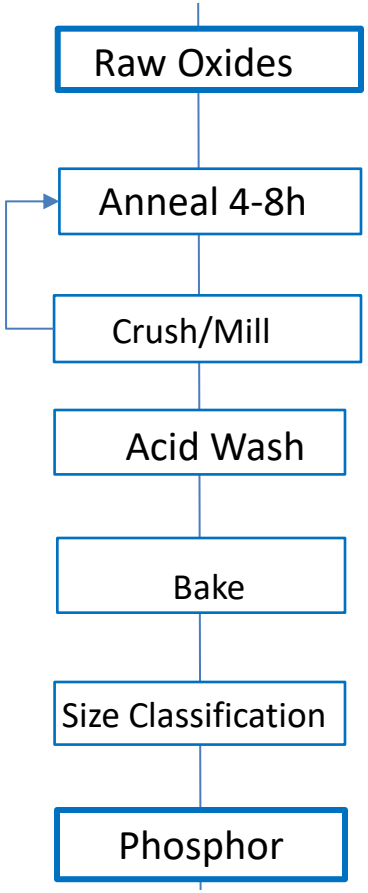
Need for a process to produce contaminant-free, phase-pure, homogeneous, and size-controlled materials

AMASTAN
The sun is the limit

Phosphor Process Impact

COMPARISON: YAG:Ce Phosphor Production

Solid State Process



Batch process, 6-8 Steps, days

VS.

UniMelt Process

Solution, solid, or gaseous precursors

CONTINUOUS process, single-step, seconds

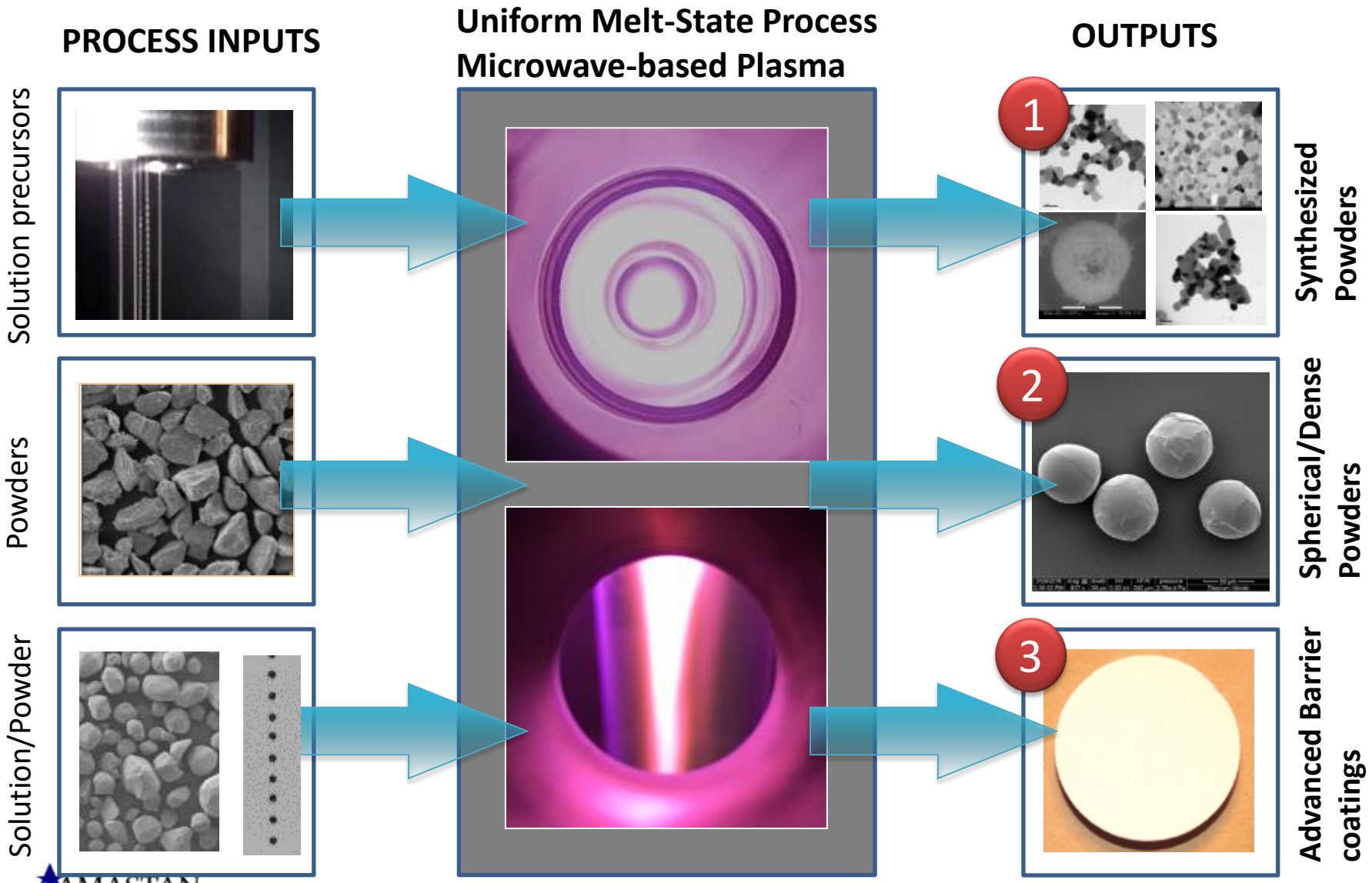
Oxide, Nitride Phosphors

Competitive Advantage

- One-step process versus 6+ step solid state process
- Continuous process that eliminates variation in batch processes
- Eliminate/minimize waste
- Spherical morphology
- Tight control of particle size and particle size distribution
- Tight control of crystal structure

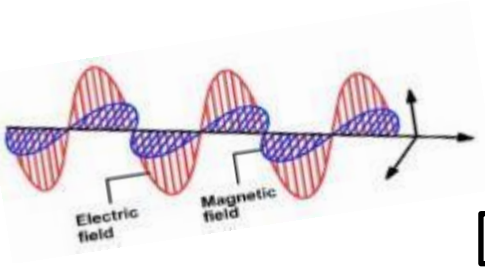
AMASTAN
The sun is the limit

UniMelt™ Technology Platform



AMASTAN
The sun is the limit

UniMelt Process



Homogeneous solution precursors

UniDrop™
Piezo droplet maker

Precursor Uniform Droplet Stream

Microwave Generator (6 kW – 200kW)

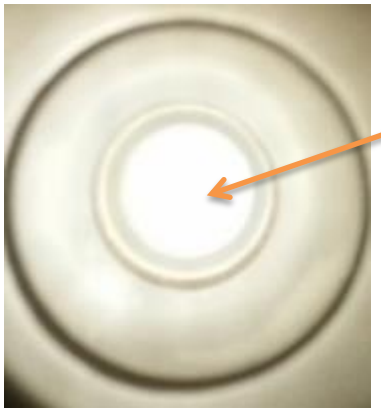
Waveguide

Axisymmetric Plasma

Plasma Chamber

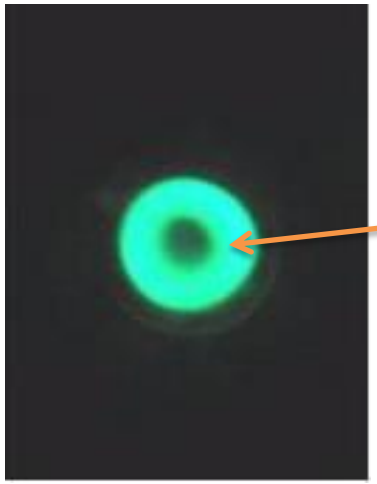
Powder Collection

Microwave Plasma



Uniform plasma

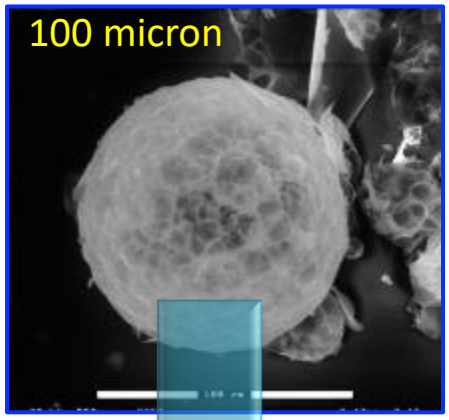
ICP Plasma



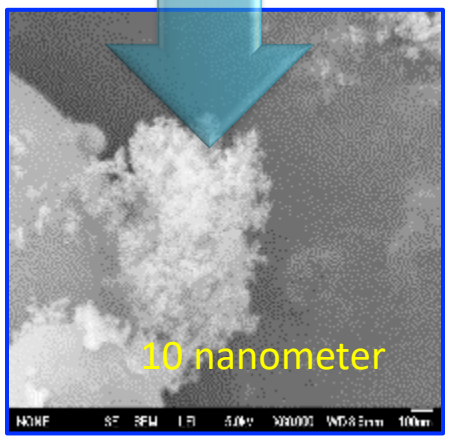
Hollow plasma

Engineer Materials at Nano Scale

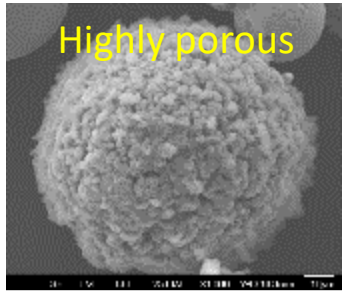
Engineered diameter

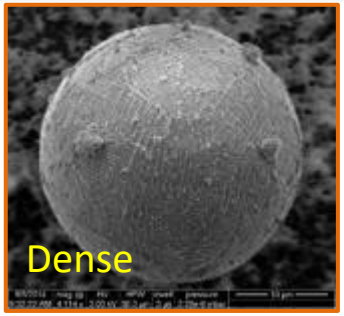


10,000x

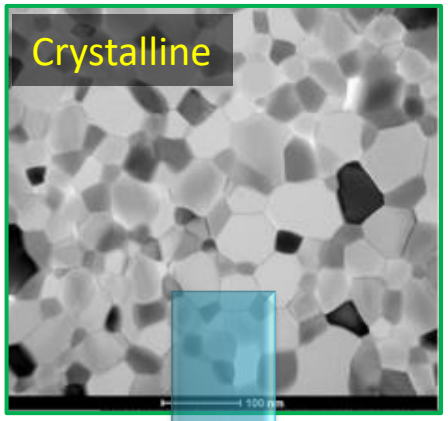


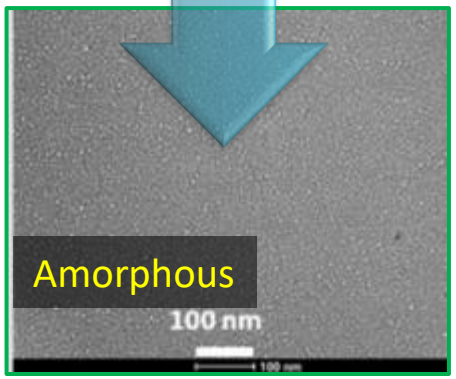
Engineered Morphology





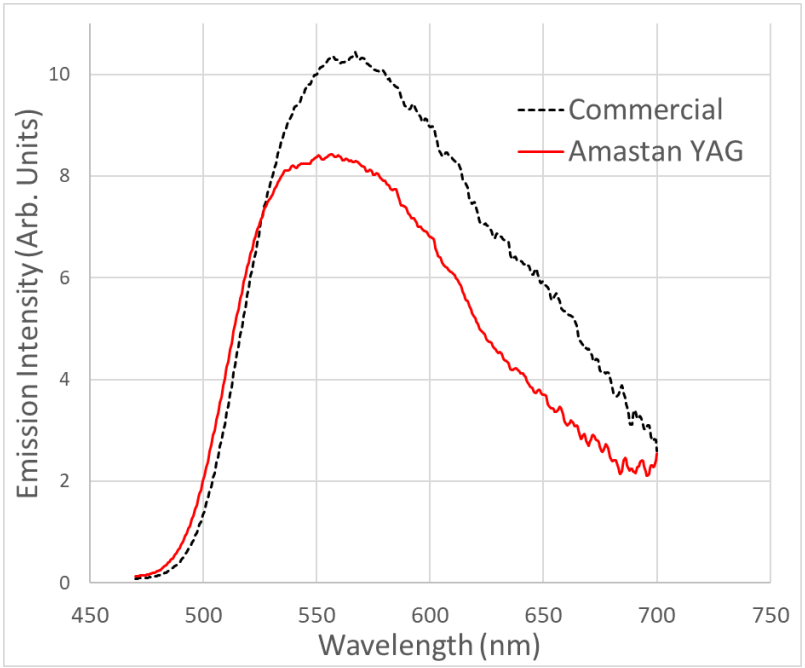
Engineered Crystallinity



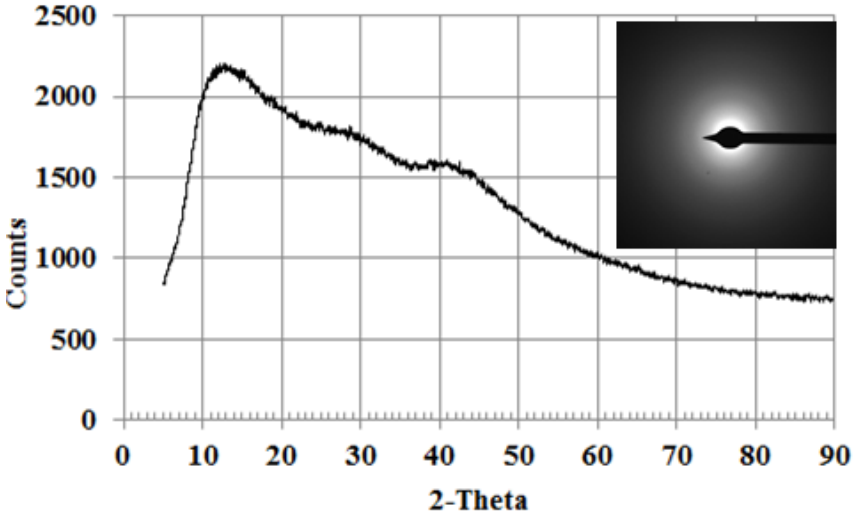


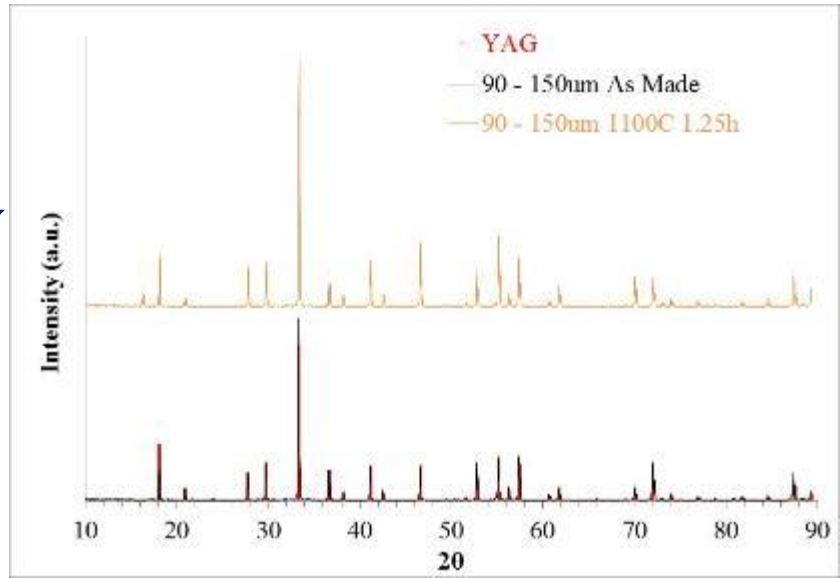
Phosphor Manufacturing: YAG:Ce

- Low cost solution precursor
- One step phase purity



Process tunability



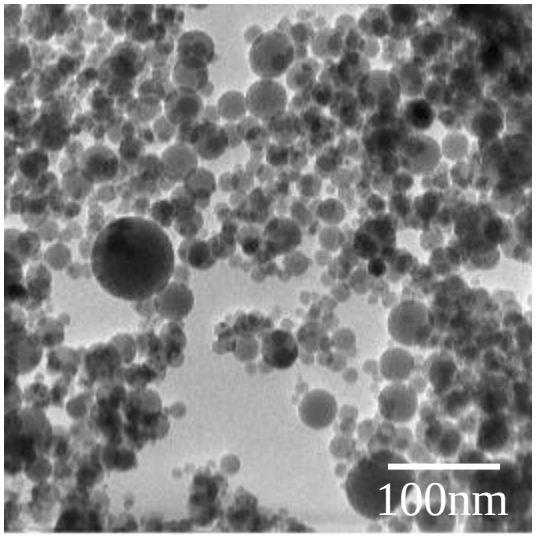


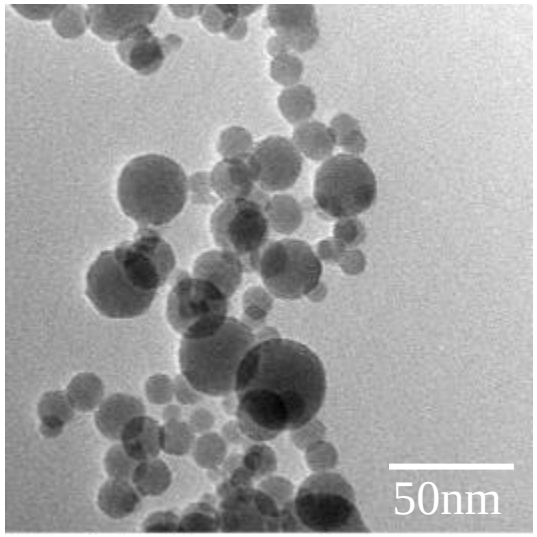
AMASTAN
The sun is the limit

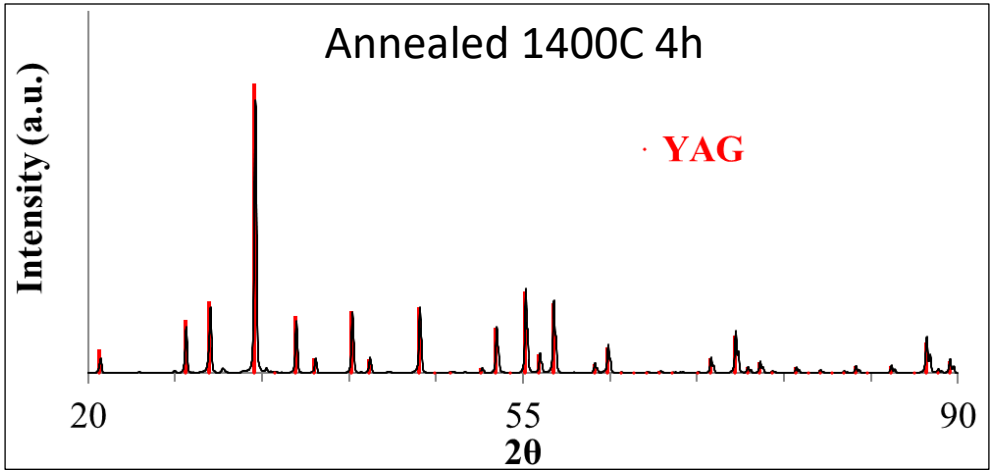
Nano YAG:Ce Phosphor ($Y_3Al_5O_{12}$:Ce)

- Preliminary results of nano-YAG:Ce made with UniMelt
  - 20 – 90nm
    - Few particles: 100nm - 10um
  - Spherical
  - Well-crystallized after annealing
    - Working towards single-step

As-Made

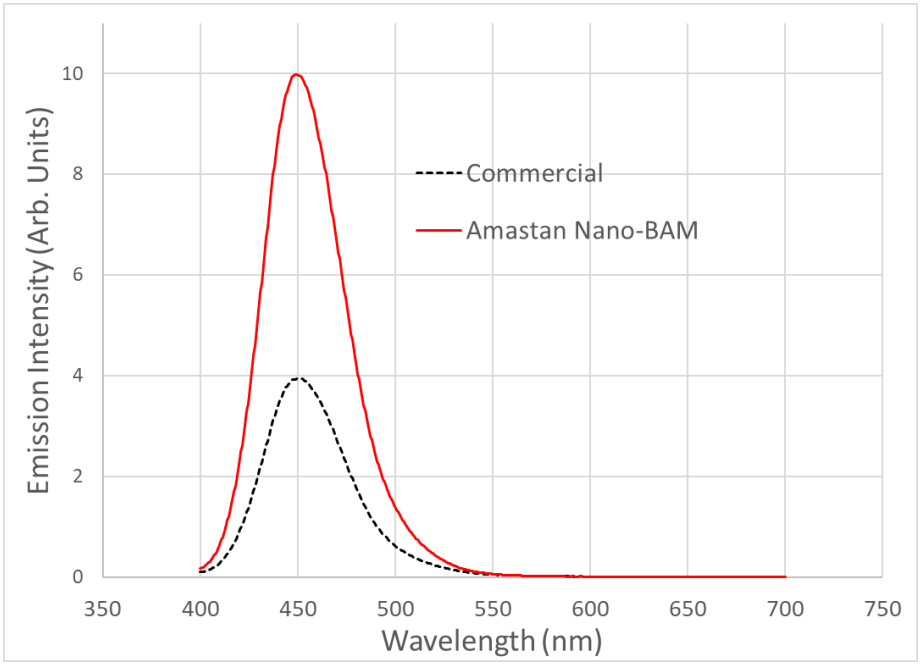


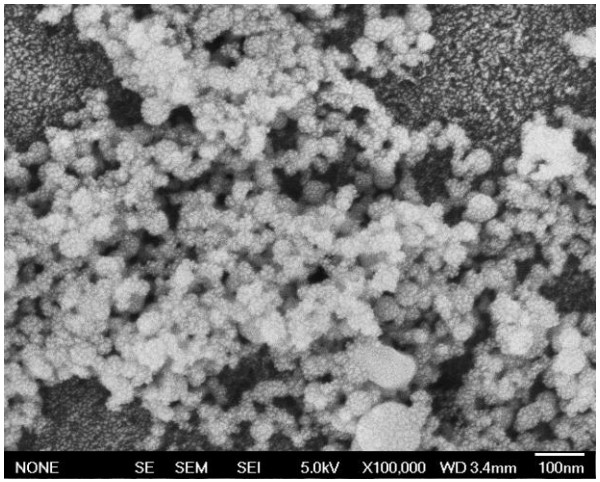


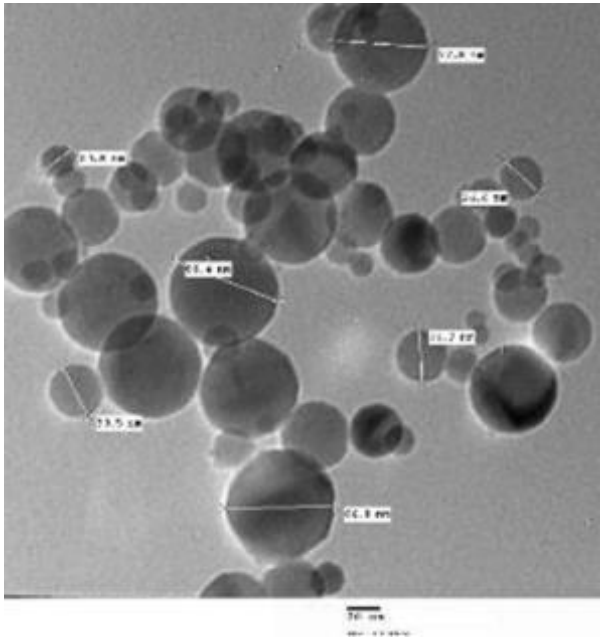


Nano-BAM Phosphor ($BaMgAl_{10}O_{17}:Eu^{2+}$)

- Production of nano phosphor with complex stoichiometry
- 40% photoluminescence of commercial large (2-3 μm) BAM







AMASTAN
The sun is the limit

Summary

- UniMelt Process provides the possibility for making materials that may not be attainable through traditional chemistry
- It allows tight control of materials characteristics through fine control or process parameters
- Can produce micron, sub-micron and nano phosphors
- Provides contamination-free environment that allows production of oxides, nitrides, etc…
- Scalable one-step process and high energy efficient allow for the production of commercial quantities of a variety of materials at a competitive price