Synthesis and Processing of Transparent Ceramic Nanocomposites

S&T Campaign: Materials Research
High Strain Rate & Ballistic Materials
Transparent Ceramics

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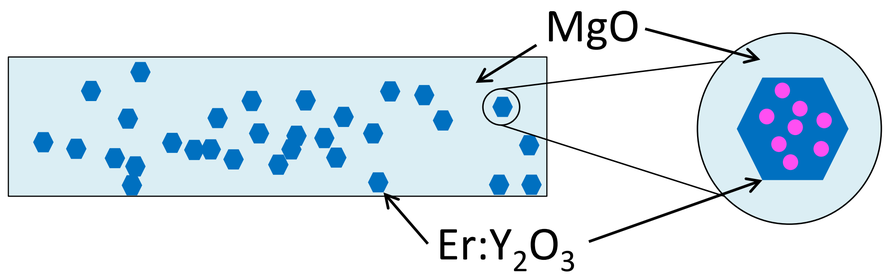
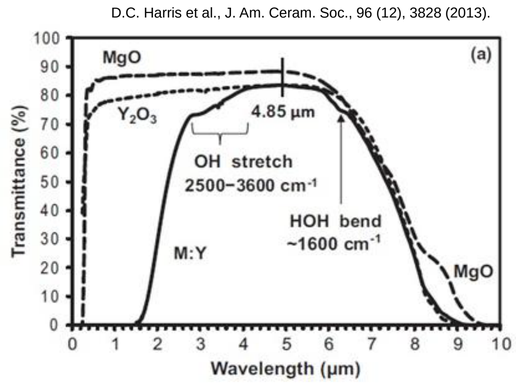
Research Objective

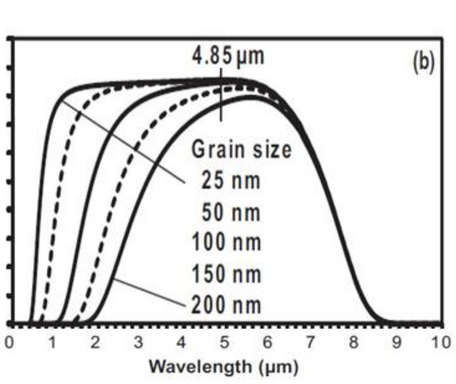
- **Minimize performance trade-off in bulk transparent materials by creating nanocomposites to optimize two competing properties simultaneously.**
- **Advance synthesis and processing science for IR-transparent, dual-phase ceramic nanocomposites for expanded functionality.**



D.C. Harris et al., J. Am. Ceram. Soc., 96 (12), 3828 (2013).



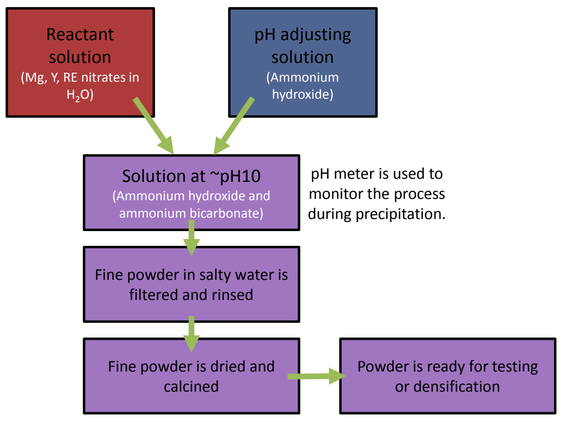
Measured transmission of single crystal MgO, Y_2O_3, and MgO:Y_2O_3 (M:Y) nanocomposite with average grain size of ~150 nm.

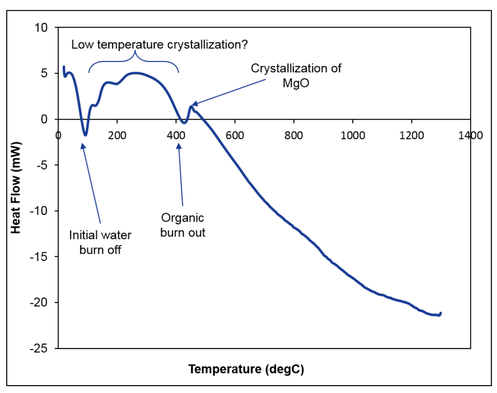


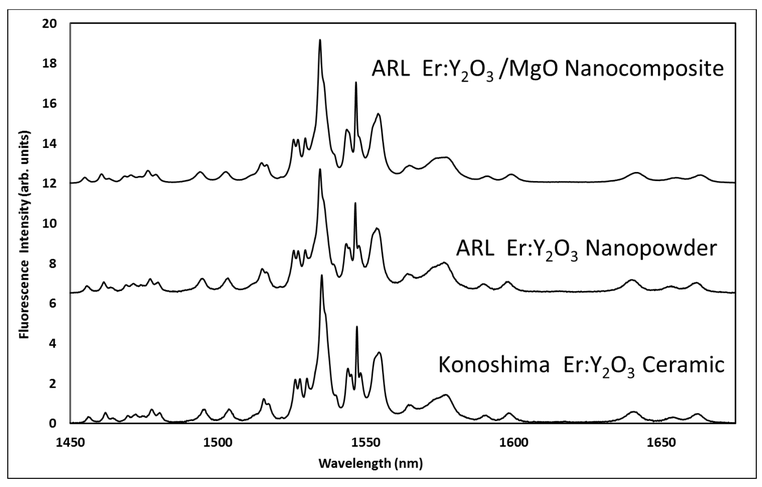
Predicted transmission of MgO:Y_2O_3 as a function of grain size.

Challenges

- **Densification of nanocomposites in order to promote bulk mass transfer without high grain boundary mobility.**
- **Development of a homogeneous microstructure with near theoretical density for maximum transparency at the wavelength of interest.**





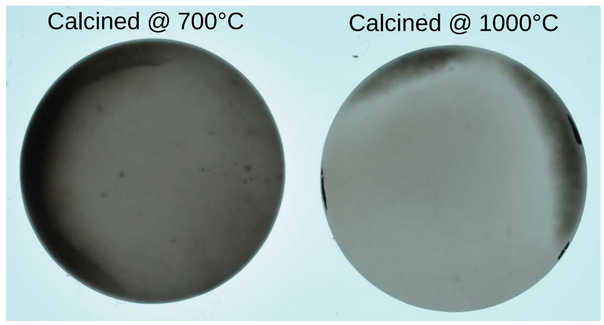


Fluorescence of ARL developed nanocomposite powders shows similar response to single phase Er:Y_2O_3 and transparent Er:Y_2O_3 monolith.

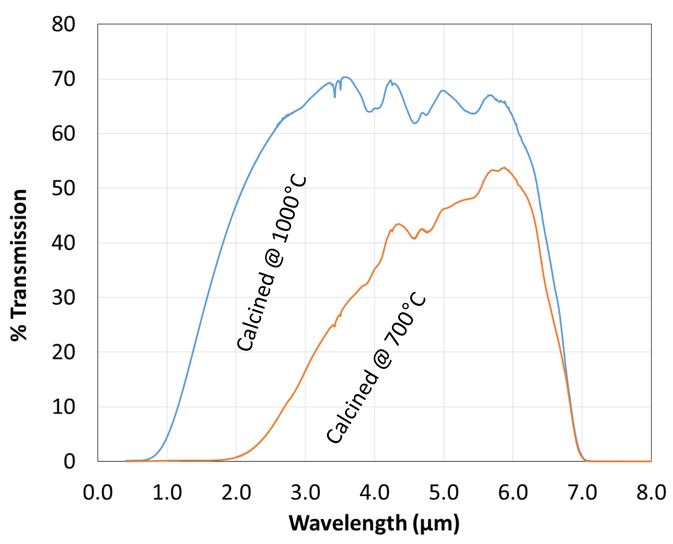
ARL Facilities and Capabilities Available to Support Collaborative Research

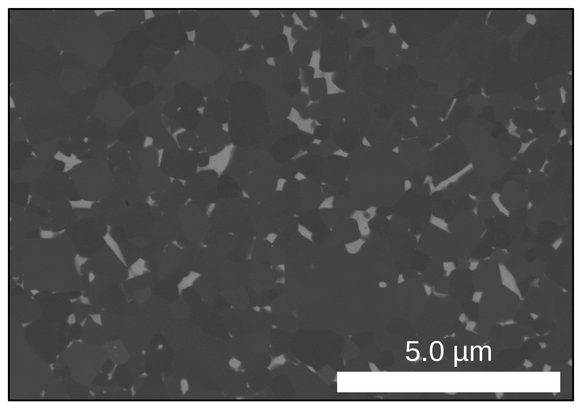
- **Advance capability in high temperature processing of transparent ceramics including:**
  - **Hot Isostatic Pressing (2000°C, 30ksi)**
  - **Hot Uniaxial Pressing (2000°C, 6100psi)**
  - **Electric Field Assisted Sintering**
  - **Single Mode Microwave Sintering (915 MHz & 2.45 GHz, 2000°C, 5000 psi)**
  - **Thermomagnetic Processing (2200°C, 5000psi, 9T)**

Calcination Temperature (°C)	Dwell Time (min)	Density (g/cm^3)
700	10	3.56
1000	10	3.61



Back lit image of 1 inch diameter discs.





Microstructure of the 1000°C part.

Improvement in transmission spectra is observed upon an increase in sample density.

Next step is to show a reduced grain size to further improve the transmission.

Complementary Expertise / Facilities/ Capabilities Sought in Collaboration

- **ARL seeks collaborators with expertise and capability in the areas of:**
  - **TEM sample preparation and imaging to determine:**
    - **Homogeneity of rare earth dopant throughout the material**
    - **Microstructure of submicron grains and grain boundaries**
  - **Modeling and simulation to determine:**
    - **Ideal processing parameters**
    - **Microstructural evolution**
    - **Potential material systems**
  - **Access to synchrotron X-rays to calculate lattice parameters and strain.**