Over the past several years there has been an ongoing search for nanometer sized powered phosphors with superior performance characteristics over their micrometer counterparts. This research has been stimulated by the fact that significant changes in the optical properties have been observed with decreasing particle size. Much of this recent work has focused on the nanometer equivalent of the common red phosphor europium doped cubic Y₂O₃.

Lately our research group’s attention was shifted to rare-earth doped lutetium oxide (Lu₂O₃) nanocrystals as it has been observed that when comparing the emission properties of Y- and Lu-containing oxide and fluoride crystals, the stronger luminescence is observed for the Lu-containing crystals. Here, we present a detailed examination of the luminescent properties of both nanocrystalline and bulk Lu₂O₃ doped with 1 mol% Eu²⁺ synthesized using a combustion (propellant) synthesis technique and solid state reaction respectively.

Lu₂O₃ is isostructural to Y₂O₃ and crystallizes in a cubic bixbyite structure with space group Ia3. This lattice contains two distinct crystallographic sites for rare earth ions with point-group symmetries C₂ and C₃₅. The selection rules for Eu²⁺ ions in the C₂ symmetry site allow for electric dipole transitions while only magnetic dipole transitions such as the ⁵D₀ → ²F₁ for the C₃₅ symmetry site are allowed since it possesses a center of inversion, thus transitions originating from Eu³⁺ (C₃₅) ions are expected to possess a long lifetime compared to Eu²⁺ (C₂) ions.

Under UV excitation into the Eu-O charge transfer band at 257 nm emission from both europium ions in both crystallographic sites can be observed in the orange-red region of the spectrum (Figure 1). The emission from the two sites was separated on the basis of the difference in decay times and utilizing site selective spectroscopy. Site selective spectroscopy revealed that energy transfer from Eu³⁺ (C₃₅) → Eu²⁺ (C₂) and Eu²⁺ (C₂) → Eu³⁺ (C₃₅) ions occur at room temperature in both the bulk and nanocrystalline samples (Figure 2a and 2b). The Eu³⁺ (C₃₅) → Eu²⁺ (C₂) transfer process was found to be active at 78K while the Eu³⁺ (C₂) → Eu²⁺ (C₃₅) transfer was not as it is a thermalized process. The decay times for the peaks at the various excitation wavelengths at 300K and 78K were also recorded. Differences in the spectra and decay times between the nanocrystalline and bulk samples will be explained based on the difference in the crystallite size.

Figure 1: Emission spectrum of bulk and nanocrystalline Lu₂O₃:Eu²⁺ 1mol% at 300K excited at 257.25 nm.

Figure 2a: ⁵D₀ → ²F₁, ²F₂ emission for selective excitation into the ⁵D₀ level of nanocrystalline sample. Spectra are normalized on the 611 nm emission line.

Figure 2b: ⁵D₀ → ²F₁, ²F₂ emission for selective excitation into the ⁵D₀ level of bulk sample. Spectra are normalized on the 611 nm emission line.