

# SITE SELECTIVE LASER SPECTROSCOPY OF $\text{Eu}^{3+}$ DOPED NANOCRYSTALLINE AND BULK CUBIC $\text{Lu}_2\text{O}_3$

J. C. Boyer<sup>a</sup>, F. Vetrone<sup>a</sup>, J. A. Capobianco<sup>a</sup>,  
A. Speghini<sup>b</sup> and M. Bettinelli<sup>b</sup>

<sup>a</sup>Department of Chemistry and Biochemistry, Concordia University, 1455 de Maisonneuve Blvd. W, Montreal, Canada

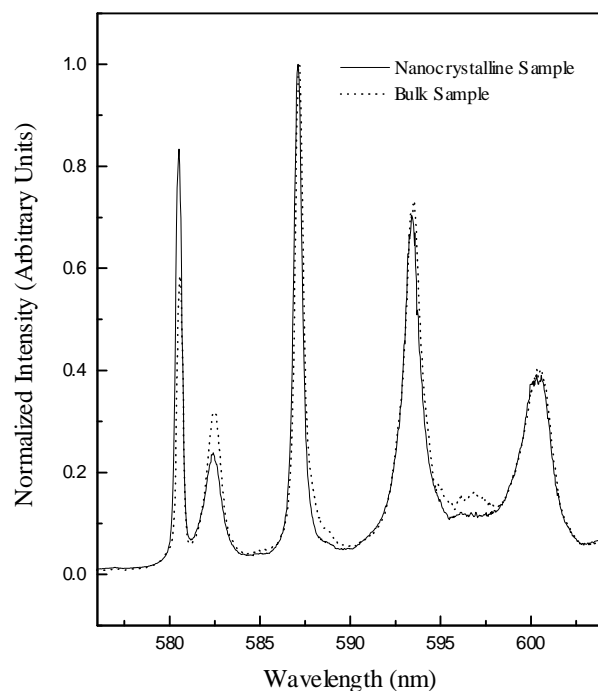
<sup>b</sup>Dipartimento Scientifico e Tecnologico, Università di Verona, Ca' Vignal, Strada Le Grazie 15, I-37134 Verona, Italy

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  $\text{Y}_2\text{O}_3$ .

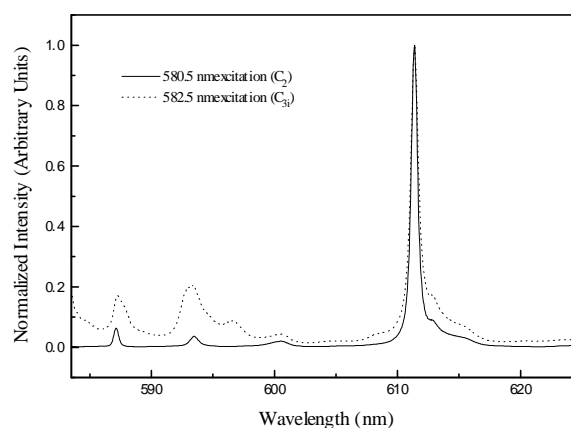
Lately our research group's attention was shifted to rare-earth doped lutetium oxide ( $\text{Lu}_2\text{O}_3$ ) nanocrystals as it has been observed that when comparing the emission properties of Y- and Lu-containing oxide and fluoride crystals, the stronger luminescence is observed for the Lu-containing crystals. Here, we present a detailed examination of the luminescent properties of both nanocrystalline and bulk  $\text{Lu}_2\text{O}_3$  doped with 1 mol%  $\text{Eu}^{3+}$  synthesized using a combustion (propellant) synthesis technique and solid state reaction respectively.

$\text{Lu}_2\text{O}_3$  is isostructural to  $\text{Y}_2\text{O}_3$  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  $C_2$  and  $C_{3i}$ . The selection rules for  $\text{Eu}^{3+}$  ions in the  $C_2$  symmetry site allow for electric dipole transitions while only magnetic dipole transitions such as the  $^5D_0 \rightarrow ^7F_1$  for the  $C_{3i}$  symmetry site are allowed since it possesses a center of inversion, thus transitions originating from  $\text{Eu}^{3+}$  ( $C_{3i}$ ) ions are expected to possess a long lifetime compared to  $\text{Eu}^{3+}$  ( $C_2$ ) ions.

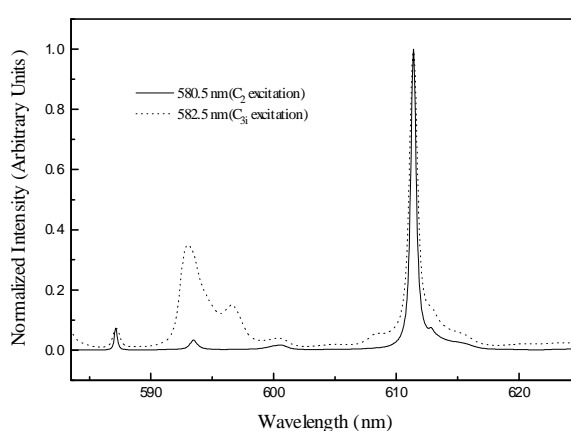
Under UV excitation into the Eu-O charge transfer band at 257 nm emission from both europium ions in both crystallographic sites can be observed in the orange-red region of the spectrum (Figure 1). The emission from the two sites was separated on the basis of the difference in decay times and utilizing site selective spectroscopy. Site selective spectroscopy revealed that energy transfer from  $\text{Eu}^{3+}$  ( $C_{3i}$ )  $\rightarrow$   $\text{Eu}^{3+}$  ( $C_2$ ) and  $\text{Eu}^{3+}$  ( $C_2$ )  $\rightarrow$   $\text{Eu}^{3+}$  ( $C_{3i}$ ) ions occur at room temperature in both the bulk and nanocrystalline samples (Figure 2a and 2b). The  $\text{Eu}^{3+}$  ( $C_{3i}$ )  $\rightarrow$   $\text{Eu}^{3+}$  ( $C_2$ ) transfer process was found to be active at 78K while the  $\text{Eu}^{3+}$  ( $C_2$ )  $\rightarrow$   $\text{Eu}^{3+}$  ( $C_{3i}$ ) 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  $\text{Lu}_2\text{O}_3:\text{Eu}^{3+}$  1mol% at 300K excited at 257.25 nm.



**Figure 2a:**  $^5D_0 \rightarrow ^7F_1, ^7F_2$  emission for selective excitation into the  $^5D_0$  level of nanocrystalline sample. Spectra are normalized on the 611 nm emission line.



**Figure 2b:**  $^5D_0 \rightarrow ^7F_1, ^7F_2$  emission for selective excitation into the  $^5D_0$  level of bulk sample. Spectra are normalized on the 611 nm emission line.