INVESTIGATION OF THE ENERGY TRANSFER MECHANISMS IN Ho^{3+} - Eu^{3+} CO-DOPED NANOCRYSTALLINE Y_2O_3

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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 Y_2O_3.

In this paper we report on the spectroscopic studies of a typically utilized red phosphor Y_2O_3: 1 mol% Eu^{3+} co-doped with 1 mol% Ho^{3+}. Two nanocrystal samples synthesized through solution combustion and wet chemical methods were examined. Both synthesis routes provide crystallite sizes in the nanometer range but with differing morphologies. A micron sized sample of similar composition was also synthesized through conventional ceramic techniques for comparative purposes.

Under 457.9 nm excitation, an energy transfer process occurs, that affects both the emissive and lifetime properties of excited states. For instance, a quenching of the green ($^5F_4$, $^5S_2 \rightarrow {}^5I_8$) Ho^{3+} emission is noted upon the presence of the Eu^{3+} ion. This is reflected in the decay time of the ($^5F_4$, $^5S_2$) levels which exhibits single exponential behavior in the case of a bulk Y_2O_3:Ho^{3+} sample but becomes shorter and non-exponential upon co-doping. As seen in Figure 1, the quenching of the green luminescence is more pronounced in the nanocrystalline samples compared to the conventional micron sample. Excitation with 257.25 nm radiation into the Eu-O charge transfer band results in luminescence almost exclusively from the Eu^{3+} ion. This observations indicate that while the $Ho^{3+} \rightarrow Eu^{3+}$ energy transfer is efficient at current doping levels the $Eu^{3+} \rightarrow Ho^{3+}$ energy transfer is not.

The effect of Eu^{3+} presence on the upconversion properties (conversion of near IR to visible light) of the Ho^{3+} ion is also examined. The upconversion efficiency is reduced in the co-doped sample with respect to the singly doped sample due to depopulation of the $^5I_7$ level by an energy transfer process to the $^7F_6$ level of the Eu^{3+} ion.

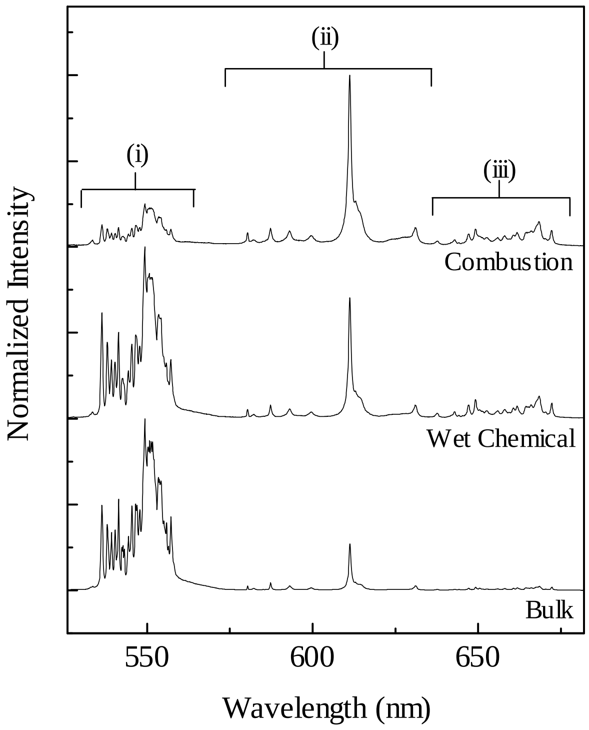

Figure 1: RT luminescence of Y_2O_3:Eu^{3+}, Ho^{3+} samples upon excitation at 457.9 nm. (i) ($^5F_4$, $^5S_2$) → $^5I_8$ [Ho^{3+}] (ii) $^5D_0 \rightarrow {}^7F_0, {}^7F_1, {}^7F_2$ [Eu^{3+}] (iii) $^5F_5 \rightarrow {}^5I_8$ [Ho^{3+}]

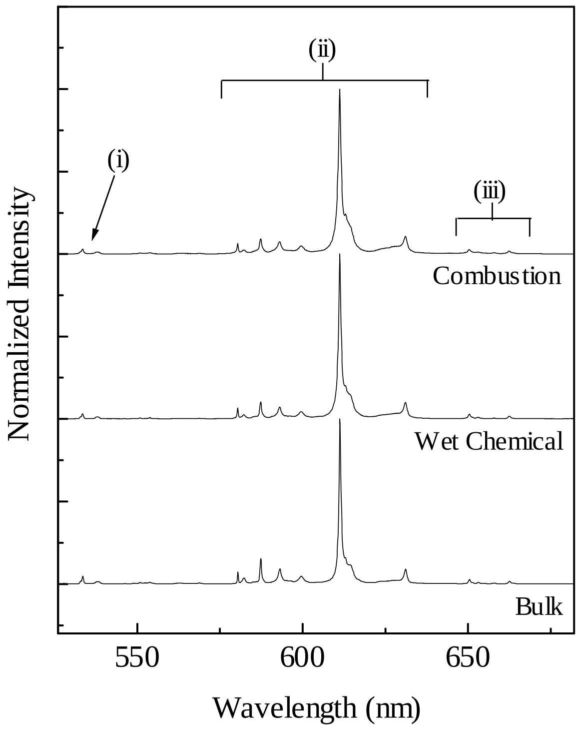

Figure 2: RT luminescence of Y_2O_3:Eu^{3+}, Ho^{3+} samples upon excitation at 257.25 nm. (i) $^5D_1 \rightarrow {}^7F_0$ [Eu^{3+}]
(ii) $^5D_0 \rightarrow {}^7F_0, {}^7F_1, {}^7F_2$ [Eu^{3+}] (iii) $^5D_0 \rightarrow {}^7F_3$ [Eu^{3+}]