ANTI-STOKES LUMINESCENCE FROM ERBIUM AND ERBIUM/YTTERBIUM DOPED YTTRIUM OXIDE NANOPARTICLES

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The search for novel light emitting materials has been the subject of continuous study since the early part of the previous century. Recently, new techniques have been developed that allow for the facile synthesis of rare earth doped phosphors with particle sizes in the nanometer regime. Thus, tailoring the size of many of the most commonly used luminescent materials has now become a distinct reality. These nano-phosphors have of late become the focus of intense investigation as their spectroscopic properties differ from the bulk counterparts due to the associated size restrictions and extraordinarily large surface.

As many electronic devices are being reduced in size, the development of phosphors with particle sizes in the nanometer regime has become vital. An excellent example is the development of flat panel displays where design constraints severely limit the amount of power available for the excitation of phosphors. Consequently, there is an ongoing search for luminescing materials with increased efficiency and smaller size. Furthermore, nanoparticles doped with rare earth ions have allowed researchers to utilize the upconversion properties of these materials for such diverse applications as upconversion phosphors and fluorescence resonance energy transfer (FRET) immunoassays.

Cubic Y_2O_3 nanoparticles doped with varying concentrations of Er_2O_3 and Yb_2O_3 were prepared using a solution combustion (propellant) synthesis procedure starting from an aqueous solution containing glycine, $Y(NO_3)_3 \cdot 6H_2O$ and $Er(NO_3)_3 \cdot 6H_2O$, with an average particle size of approximately 20 nm. For purposes of comparison, bulk samples of equal concentrations were prepared by mixing Y_2O_3 and Er_2O_3/Yb_2O_3, pressing the powders into pellets under 10 tons of pressure and firing them in air at 1500 °C for 48 hours.

Continuous wave excitation (980 nm) into both the $^4I_{11/2} \leftarrow {}^4I_{15/2}$ transition of the erbium ion and the $^2F_{5/2} \leftarrow {}^2F_{7/2}$ transition of the ytterbium ion produced intense anti-Stokes luminescence spectra with different green/red relative intensities (Figure 1). Green emission was observed centered at 525 nm and 550 nm and is assigned to the $^2H_{11/2} \rightarrow {}^4I_{15/2}$ and $^4S_{3/2} \rightarrow {}^4I_{15/2}$ transitions respectively. Red emission from the $^4F_{9/2} \rightarrow {}^4I_{15/2}$ transition was observed centered at 660 nm.

In this paper, we discuss the various mechanisms that lead to the different upconversion luminescence spectra in $Y_2O_3:Er^{3+}$ and $Y_2O_3:Er^{3+}$, Yb^{3+}.

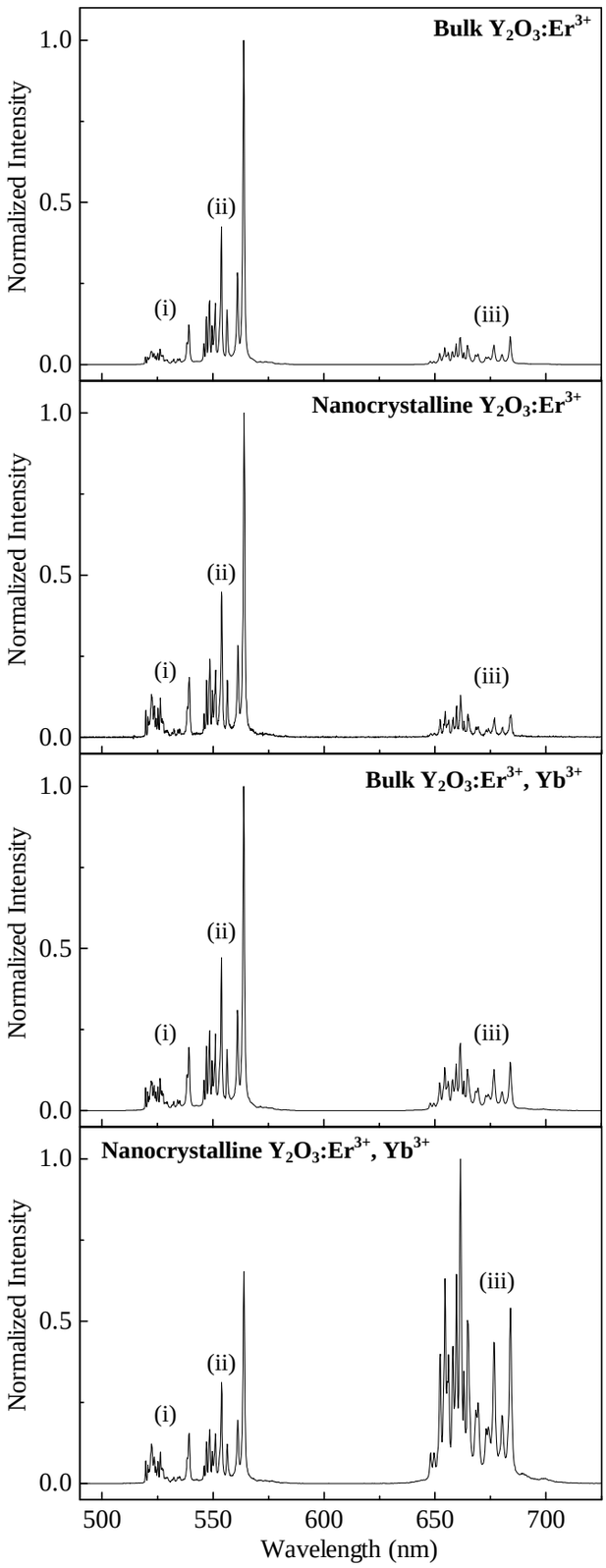

Figure 1: Anti-Stokes emission of bulk/nanocrystalline $Y_2O_3:Er^{3+}$ and $Y_2O_3:Er^{3+}$, Yb^{3+} at room temperature, showing (i) $^2H_{11/2} \rightarrow {}^4I_{15/2}$ (ii) $^4S_{3/2} \rightarrow {}^4I_{15/2}$ (iii) $^4F_{9/2} \rightarrow {}^4I_{15/2}$ transitions (λ_{exc} = 980 nm)