Poster

Synthesis, characterization and optical properties of luminescent nanocrystals

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Introduction

Upconversion (UC) is an efficient way to convert two or more low energy photons to obtain higher energy emitted light from excited energy levels. UC materials have attracted significant attention as potential solid state visible lasers, biological fluorescence labels or in order to improve solar cells efficiency [1,2]. It is well known that Yb^{3+} is an excellent UC sensitizer. The ability of this ion to induce UC is based on the high oscillator strength of the Yb^{3+} $^2F_{7/2} \rightarrow {}^2F_{5/2}$ transition, which is located in the NIR just in the range of inexpensive diode lasers.

Experimental

Rare earth ions doped nanocrystalline oxide materials have been prepared using different synthesis procedures. Nanosized cubic Y_2O_3: Er^{3+}, Yb^{3+} crystals have been obtained by both mechanochemical synthesis in a planetary ball mill [3] and the following combustion reaction [4],

$$3M\left(NO_3\right)_3 + 5NH_2CH_2COOH + 9O_2 \rightarrow 3/2M_2O_3 + 5/2N_2 + 9NO_2 + 10CO_2 + 25/2H_2O$$

$Gd_3Ga_5O_{12}$ (GGG) and $Y_3Al_5O_{12}$ (YAG) nanocrystalline powders doped with different Yb^{3+} and rare earth combinations have been prepared by Pechini´s method [5]. The SiO_2 coating of the as-synthesized nanoparticles has been carried out following the Stöber method [6].

The nanocrystalline size has been estimated from X-ray diffraction (XRD) diagrams and transmission electron microscopy (TEM) measurements. Optical properties such as emission and excitation spectra or lifetime measurements have been studied. A detailed investigation of the spectroscopy and the excited state dynamics is extremely interesting in order to determine the mechanisms involved in the UC processes.

Results

From XRD and TEM measurements it can be seen that with all synthesis procedures, ball milling, combustion and Pechini's method, nanoparticles of about 50 nm in size are obtained (Fig 1). All prepared samples show intense UC emission after IR excitation (see Fig. 2 as an example). The UC processes involved in Y_2O_3: Er^{3+}, Yb^{3+} can be ascribed to GSA/ESA (Ground-State-Absorption / Excited-State-Absorption) or GSA/ETU (Ground-State-Absorption / Energy-Transfer-Upconversion). However, the

situation is completely different for Tb^{3+} and Eu^{3+}ions which have no intermediate levels resonant with Yb^{3+}. SiO_2 coating preserves the nanoparticles from surface contamination and does not affect the optical properties. This is relevant for the eventual functionalization of the nanocrystals.

References

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Figures

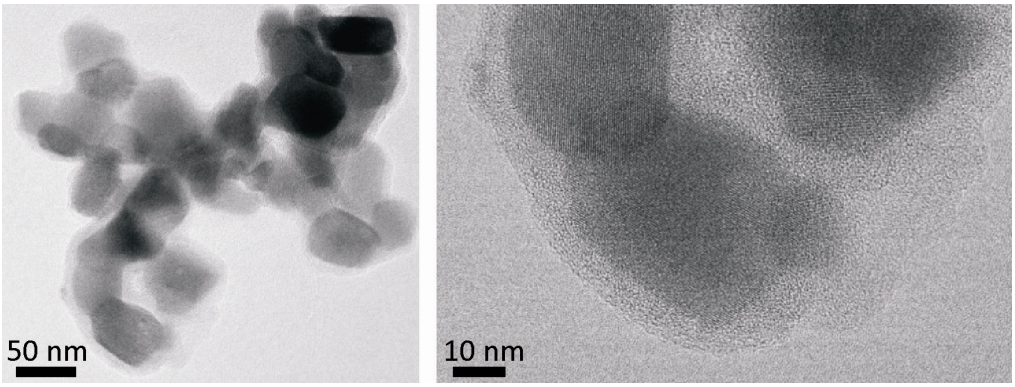

Fig. 1: TEM image of Y_2O_3: 2%Er^{3+}, 1%Yb^{3+} prepared by combustion after SiO_2 coating.

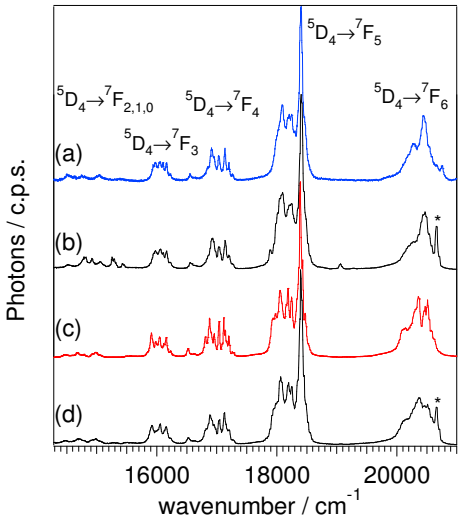

Fig. 2: RT luminescence spectra of GGG: 2%Tb^{3+} 5%Yb^{3+} exciting at 37040 cm^{-1} (a) and 10250 cm^{-1} (b). RT emission spectra of YAG: 2%Tb^{3+} 5%Yb^{3+} exciting at 37040 cm^{-1} (c) and 10250 cm^{-1} (d).