YF_3:Tm,Yb nanocrystals: enhanced up-conversion blue and UV emitters

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Fluorides doped with rare earth (RE) ions have been used in a wide range of photonic applications along the last decades. At present, the importance of nanoscale optically functional materials to be used as medical and biological tags has increased the potentiality of fluorides. To exploit those possibilities new methods to obtain several nanostructures based on fluorides are being developed, and several doping possibilities are being tried to obtain visible emissions using biologically innocuous excitation [1,2]. Recently, a novel synthesis method, providing a straightforward and versatile procedure for the synthesis of uniform lanthanide fluoride nanophosphors has been proposed [3].

At present, there is a renewed interest in YF_3 nanophosphors directed to obtain high energy luminescent emissions. Along this line, doping with Tm^{3+}&Yb^{3+} has been reported to produce enhanced blue and ultraviolet emissions [4-5]. In the present work, synthesis and optical characterization of the Tm^{3+}/Yb^{3+} co-doped YF_3 nanophosphors is reported. The dominant Tm^{3+} up-converted emission bands have been investigated by exciting the Yb^{3+} ions at around 980 nm.

The RE-doped fluoride nanoparticles were prepared by a homogeneous precipitation reaction in ethylene glycol solutions containing the rare earth precursors and [BMIM]BF_4 as a source of fluoride ions [3]. In order to investigate the effects of the doping level on the optical properties of the nanophosphors, the Yb^{3+} content was varied in the range 10-20% molar while the Tm^{3+} concentration was kept constant (2% molar).

The morphology of the nanoparticles was examined by transmission electron microscopy using a TEM Philips 200CM system. Qualitative composition of the particles was assessed by energy dispersive X-ray analysis using an EDX system (Philips DX4) coupled to an electron microscope. The crystalline structure of the particles was assessed by X-ray diffraction. The optical characterization has been performed using a Ti:Za laser pumped with an Ar-laser to excite Yb^{3+} ions. The visible Tm^{3+} luminescence was dispersed by using an ARC Spectrapro 500-I monochromator and then detected with a photomultiplier tube.

In Figure 1 a TEM image of the Tm^{3+}/Yb^{3+}-doped nanophosphors can be seen, illustrating the morphology and uniformity of the obtained nanocrystals.

Figure 2 shows the visible emissions in the wavelength range 300 nm < λ < 810 nm, arising from Tm^{3+} ions after Yb^{3+} excitation at λ = 980 nm. These results demonstrate that effective co-doping has been achieved, providing the adequate conditions for effective energy transfer between Yb^{3+} and Tm^{3+} ions, with effective blue and UV up-conversion.

References:

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Figures:

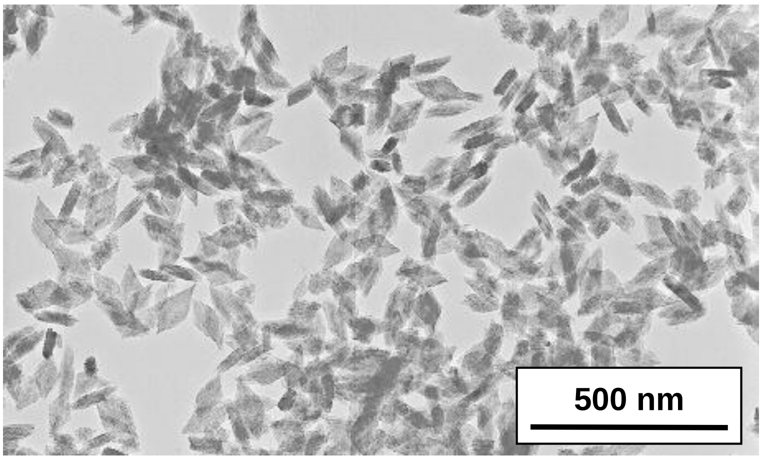

Figure 1. TEM image of the Tm^{3+}/Yb^{3+}-doped nanophosphors.

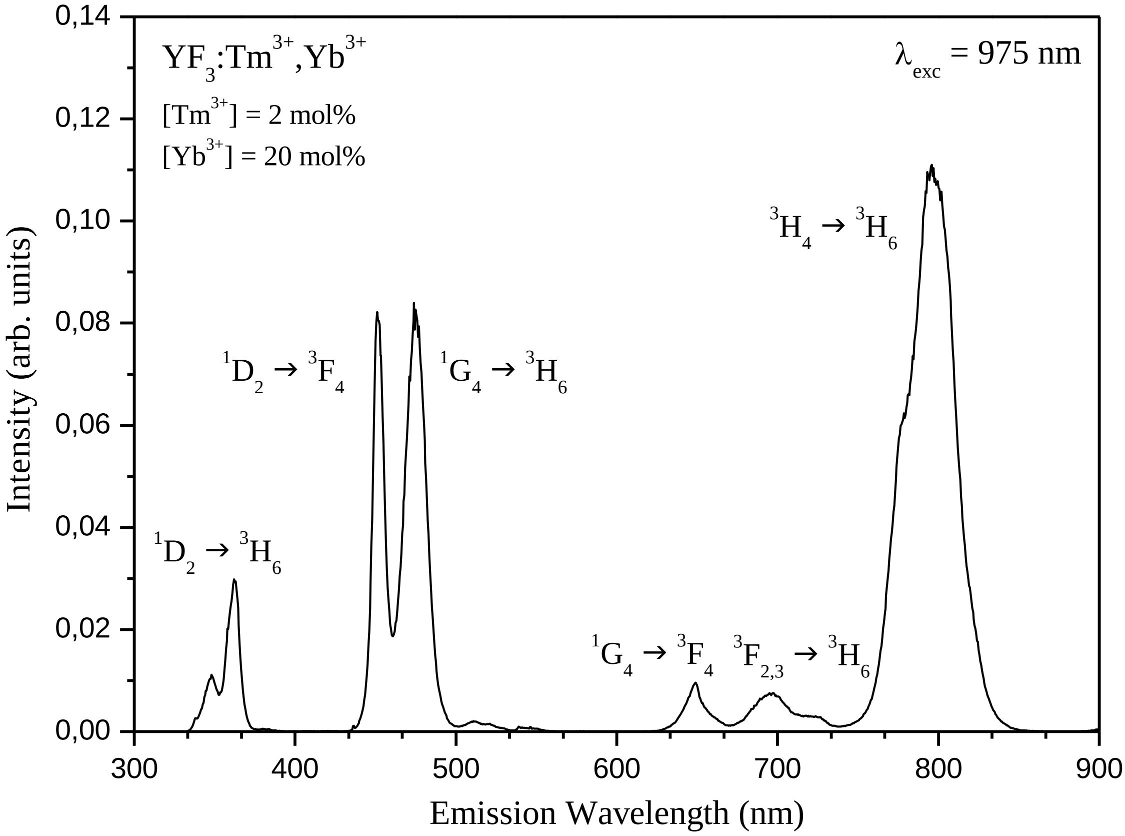

Figure 2. Emission spectra of $[Tm^{3+}]$ = 2 mol% and $[Yb^{3+}]$ = 20 mol% co-doped samples by pumping at 975 nm.