Optical characterization of up-conversion properties of fluorescent $NaYF_4$:Er,Yb nanocrystals

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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].

In the present work, a detailed optical characterization of the Er^{3+}/Yb^{3+} co-doped $NaYF_4$ nanophosphors so synthesised is reported. The dominant Er^{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 NaF as a source for both, fluoride and sodium 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 Er^{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 optical characterization has been performed using a JENOPTIK laser diode source to excite the Yb^{3+} ions with different excitation powers. The visible Er^{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 Er^{3+}/Yb^{3+}-doped nanophosphors can be seen, illustrating the morphology and uniformity of the obtained nanocrystals.

Figure 2 shows the visible emission in the wavelength range $400\ nm < \lambda < 750\ nm$, arising from Er^{3+} ions after Yb^{3+} excitation at $\lambda = 980$ nm. These results demonstrate that effective co-doping has been achieved, providing the adequate conditions for effective energy transfer between Yb^{3+} and Er^{3+} ions. It is also apparent that the emission spectra strongly depend on the excitation power, as it is expected from the spectroscopic properties of Er^{3+}/Yb^{3+} activated materials [4].

References:

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Figures:

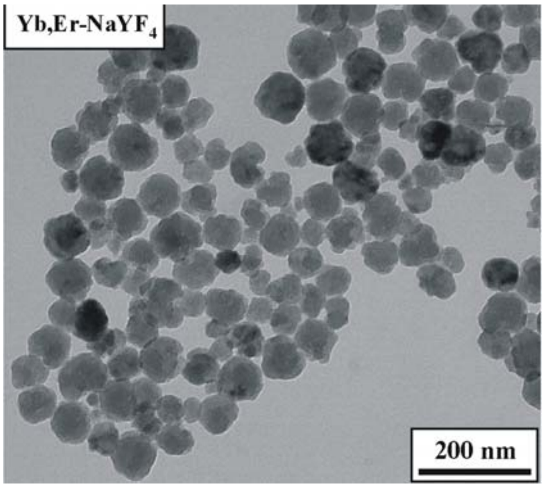

Figure 1. TEM image of the Er^{3+}/Yb^{3+}-doped nanophosphors.

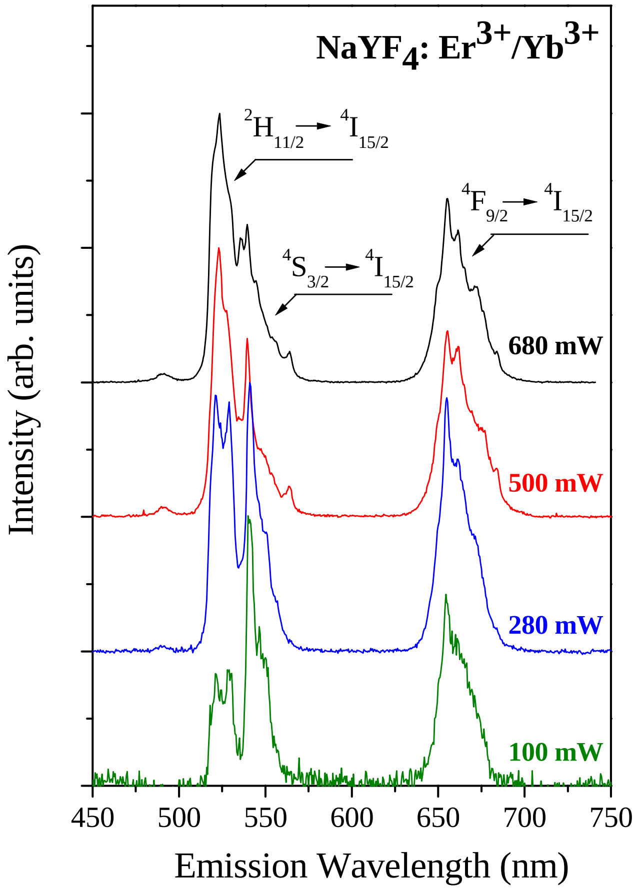

Figure 2. Emission spectra of $[Er^{3+}]$ = 2 mol% and $[Yb^{3+}]$ = 10 mol% codoped samples. The different spectra were measured by pumping at 980 nm with different excitation powers.