Tuneable up-conversion phosphor based in sol-gel derived nano-glass-ceramics containing Yb^{3+}-Er^{3+} co-doped $NaYF_4$ nanocrystals

A. Santana-Alonso[a], A. C. Yanes[a], J. Méndez-Ramos[b], J. del-Castillo[a] and V. D. Rodríguez[b]

[a] Departamento de Física Básica
[b] Departamento de Física Fundamental y Experimental, Electrónica y Sistemas
Universidad de La Laguna, La Laguna, Tenerife, Spain
jmendezr@ull.es

Enhanced physical and optical properties of rare-earth doped nanocrystals make transparent nano-glass-ceramics a promising class of materials with potential applications in optoelectronic technology [1, 2]. $NaYF_4$ crystal is known to be one of the most efficient rare-earth ions host for near infrared to visible up-conversion [3]. Rare-earth doped $NaYF_4$ up-converting phosphors have been found to be useful for enhanced responsivity in the near-infrared for silicon solar cells [4], bioimaging and fluorescent probe labelling, sensitive detection of DNA and tuneable infrared phosphors for 3D optical recording [5]. Furthermore, highly transparent nanostructured rare-earth doped glass-ceramics can be obtained by thermal treatment of precursor glasses prepared by the easy and low cost room-temperature sol-gel method [6]. In this work nano-glass-ceramics containing Yb^{3+}-Er^{3+} co-doped $NaYF_4$ nanocrystals have been successfully developed for the first time by thermal treatment of precursor sol-gel derived glasses with composition $95SiO_2$-$5NaYF_4$ co-doped with 0.3 Yb^{3+} and 0.1 Er^{3+} (mol %). X-ray diffraction confirms the precipitation of $NaYF_4$ nanocrystals during heat treatment and their corresponding sizes have been calculated by using Scherrer's equation, obtaining values in the range 4.1–9.6 nm, corresponding to 550 and 650 ºC treatment temperatures, respectively.

Visible up-conversion luminescence has been obtained under infrared excitation at 980 nm, see Fig. 1. Up-conversion emission bands present sharp structure with well-resolved Stark components indicative of the incorporation of the rare-earth ions into precipitated nanocrystals. A remarkable change in the intensity ratio of the red to green up-conversion bands as a function of heat treatment temperature can been observed, resulting in colour tuneable up-conversion phosphors with applications in optical integrated devices. Colour tuneability has been also analyzed and quantified in terms of CIE standard chromaticity diagram where the colour gradually changes from reddish to greenish part of the diagram, as shown in Fig. 1.

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Figures:

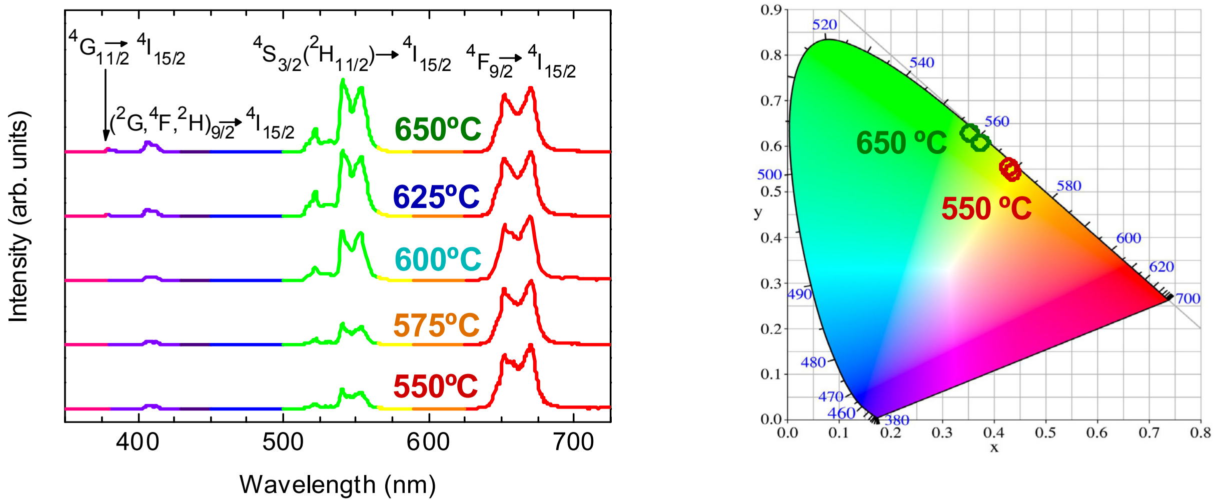

Fig. 1. Up-conversion emission spectra under 980 nm excitation at 200 mW as a function of heat treatment temperature, normalized to the maximum at 660 nm (left). Corresponding colour coordinates in the CIE chromaticity diagram of visible up-conversion emission for different heat treatment temperatures (right).