Journal of Alloys and Compounds 709 (2017) 362–372

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

journal homepage: http://www.elsevier.com/locate/jalcom

Charge compensated derived enhanced red emission from $Sr_3(VO_4)_2:Eu^{3+}$ nanophosphors for white light emitting diodes and flat panel displays

A.K. Bedyal [a, b, *], Vinay Kumar [a, b, **], H.C. Swart [a, ***]

[a] Department of Physics, University of the Free State, P.O. Box 339, Bloemfontein, ZA9300, South Africa
[b] Department of Physics, Shri Mata Vaishno Devi University, Katra, 182320, J&K, India

ARTICLE INFO

Article history:
Received 2 February 2017
Received in revised form
10 March 2017
Accepted 13 March 2017
Available online 14 March 2017

Keywords:
LEDs
FEDs
Phosphors
Orthovanadate
Solid state lighting

ABSTRACT

A near UV-light downconvertible narrow-band red emitting europium (0.5–7 mol. %) doped strontium orthovanadate nanophosphors were synthesized by a combustion method taking urea as fuel. For charge compensation, the material was also co-doped with alkali metal ions (Li^+, Na^+, K^+). Powder X-ray diffraction results revealed that the material was in rhombohedral phase with space group *R*3*m*. Calculated lattice parameters were found to be slightly changed upon doping and co-doping. Scanning electron microscopy images showed that the nanoparticles have spherical morphology. The photoluminescence and cathodoluminescence studies disclosed that the nanophosphors emitted red light under UV and electron excitation which corresponds with the characteristic emission of the Eu^{3+} ion ($^5D_0 \rightarrow {}^7F_j$, j = 1–5). Enhancement in the PL intensity of the phosphors was observed upon co-doping due to charge compensation. X-ray photoelectron spectroscopy, suggests that Eu is mostly present in (+3) valance state in the phosphor. The approximate Commission Internationale de l'Eclairage coordinates for PL (0.62, 0.35) and CL (0.61, 0.38) were found to be very close to the commercial red emitting phosphor. The results suggest that the phosphor with high color purity (85%) could be the preferred choice as a red component for white light emitting diodes and field emission displays.

1. Introduction

The escalating demand for energy in the present century has prompted the scientific community to search for efficient energy saving devices. With this in mind, much effort has been dedicated to the development of lighting sources, which has resulted in light-emitting diodes (LEDs)/white light-emitting diodes (WLEDs) as new solid state lighting (SSL) sources. The LEDs/WLEDs have advantages such as low energy consumption, extremely long life, durability, mercury free and environmental friendly, over the conventional incandescent and halogen lamps. Owing to the advantages, the LEDs/WLEDs have promising wide-range applications in the field of lighting and display technology [1,2]. Light-emitting diodes were first used in solid state lighting in the 1990s with the development of blue light-emitting diodes. This invention gave rise to the development of white emitting LEDs in 1997 by combining yellow phosphor (YAG:Ce) with a blue emitting GaN chip [3]. However, the resulting WLED had certain drawbacks in terms of a poor color rendering index (CRI) and low stability of the color temperature. To minimize these issues, the focus of WLED production shifted from a YAG:Ce phosphor blue LED based strategy to a tri-color (red, green, blue) phosphor ultraviolet LED based strategy [4,5]. The strategy gained popularity with the advent of InGaN based LEDs, because of the emission wavelength of the GaN-based blue LEDs could be varied between 370 nm (band gap of pure GaN) and 470 nm by increasing the In (Indium) content in the InGaN devices. On the other hand the work is also going on to improve the CRI and the luminous efficacy of radiation (LER) for YAG based WLEDs. Adding a red-emitting component into an LED combined with YAG is a common approach to improve the CRI and LER. But the materials have broad red emission, reduce the CRI and

* Corresponding author. Department of Physics, University of the Free State, P.O. Box 339, Bloemfontein, ZA9300, South Africa.
** Corresponding author. Department of Physics, Shri Mata Vaishno Devi University, Katra, 182320, J&K, India.
*** Corresponding author. Department of Physics, University of the Free State, P.O. Box 339, Bloemfontein, ZA9300, South Africa.
E-mail addresses: ankushbadiyal@gmail.com, bedyalak@ufs.ac.za (A.K. Bedyal), vinaykumar@smvdu.ac.in (V. Kumar), swarthc@ufs.ac.za (H.C. Swart).

http://dx.doi.org/10.1016/j.jallcom.2017.03.139
0925-8388/