Optik 160 (2018) 361–370

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Original research article

Optical studies and estimation of kinetic parameters for dysprosium activated yttrium oxide phosphors

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ARTICLE INFO

Article history:
Received 12 January 2018
Accepted 5 February 2018

Keywords:
Yttrium oxide
Dysprosium
Thermoluminescence
Photoluminescence
Correlated colour temperature

ABSTRACT

Dysprosium doped Y_2O_3 phosphors have been prepared via facile solid-state reaction (SSR) method. Cubic structure of Y_2O_3: Dy^{3+} phosphors were obtained through X-ray diffraction (XRD). FEGSEM analysis shows agglomerated irregular structures with uniform grain connectivity. The functional group analysis is done by Fourier transforms infrared spectroscopy (FTIR). The photoluminescence (PL) analysis reveals that these phosphor exhibits instance blue emission at 484 nm, 574 nm, 585 nm and 614 nm due to transitions $^4F_{9/2}$ to $^6H_{15/2}$, $^4F_{9/2}$ to $^6H_{13/2}$ and $^4F_{9/2}$ to $^6H_{11/2}$ respectively, under 570 nm excitation wavelength. The CIE coordinates, CCT and afterglow analysis were also done. Emission and cross relaxation mechanisms were explained by energy levels diagram. Thermoluminescence (TL) spectra of show intense peaks at 640K for gamma irradiated phosphors. The TL spectra were deconvoluted by computerized glow curve deconvolution (CGCD) technique. Kinetic parameters were calculated with the help of Chen's peak shape method. The recorded TL spectra show the linear behaviour with respect to variation of gamma exposures time with the activation energy varying from 15.523×10^{-1} eV to 21.906×10^{-1} eV.

1. Introduction

Rare earth (RE) doped compounds like fluorides, phosphates, vanadates, oxides and hydroxides are very popular in the field of optoelectronics [1]. Among them, oxide based phosphors have potential application in luminescent devices, security labelling and radiation detector due to their electrical, physical, chemical and photonic characteristics [2,3]. Yttrium oxide (Y_2O_3) is the most favourable host for the luminescence field because of their low thermal expansion, low phonon energy, high relative dielectric permittivity, high dielectric breakdown strength, high melting point and high chemical stability [4]. Also, Y_2O_3 is important engineering material for the production of light appliances [5–9].

RE ions such as Eu^{3+}, Yb^{3+}, Dy^{3+}, Gd^{3+}, Er^{3+}, Sm^{3+} and Tb^{3+} are mostly used as activators. Incorporation of rare earth ions in Y_2O_3 lattice will enhance the luminescence properties. Trivalent dysprosium ions have been extensively studied in various hosts due to their unique spectral properties. Dy^{3+} ions give blue (near 480 nm), greenish-yellow (near 575 nm), red (near 670 nm) and brownish-red (near 737 nm) emissions corresponds to transitions $^4F_{9/2}$ to $^6H_{15/2}$, $^4F_{9/2}$ to $^6H_{13/2}$, $^4F_{9/2}$ to $^6H_{11/2}$ and $^4F_{9/2}$ to $^6H_{9/2}$respectively, under 230–570 nm excitation and acceptable atmospheric stability and optimized degeneration over the range of applied voltages [10,11]. Moreover, Dy^{3+} doped oxide phosphors are also the best option for

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https://doi.org/10.1016/j.ijleo.2018.02.015
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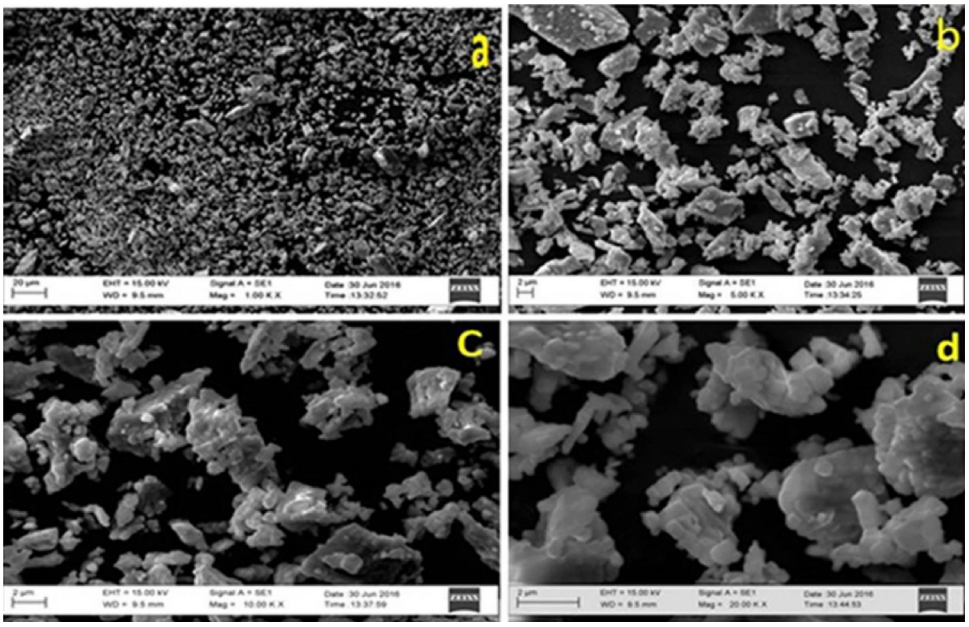

Fig. 1. SEM images of Y_2O_3:Dy^{3+}phosphors.

thermo luminescence materials because of their linear dose response, high temperature TL peaks, high activation energy and low fading effect [12].

The luminescent properties strongly depend on the type of synthesis process. Various synthesis processes are used for preparation of rare earth doped Y_2O_3 phosphors such as combustion method, co-precipitation method, hydrothermal method, micro-emulsion method, etc. [13–16].The main advantages of SSR preparation technique are suitability and simplicity of method for large-scale production of phosphors.

This paper reports the morphological and luminescent studies of Y_2O_3: Dy^{3+} phosphors which are prepared by SSR preparation techniques.

2. Experimental

Y_2O_3: Dy^{3+} powder samples were synthesized by SSR method with Y_2O_3 and Dy_2O_3 as raw materials. Stoichiometric amount of raw materials (99.9%, Sigma-Aldrich) were ground for 1hr and then calcined at 1100 °C for 1 h. This mixture is sintered at 1350 °C for 3 h then fine powdered phosphors were obtained.

The structural studies of phosphors were carried out by X-ray diffractometer (PAN Analytical PXRD), Fourier transforms infrared spectroscopy (FTIR, Alfa Bruker), scanning electron microscopy (SEM, ZEISS EVO Series) and energy dispersive X-ray (EDX, INCA 250 ZEISS) spectroscopy. PL characteristics were recorded with the help of spectrofluorophotometer (model–RF53011 Shimadzu) with a 150 W Xenon lamp. TL properties were characterized by TLD, M-TL/OSL1008 Nucleonix. The irradiation sources γ Theratron 780 E, Teletherapy unit, Co60 were used γ exposures.

3. Results and discussion

3.1. Structural and morphological analysis

3.1.1. SEM analysis

The SEM is an effective tool to study surface morphologies. The SEM images of the Dy^{3+} doped Y_2O_3 phosphor are shown in Fig. 1.

The Fig. 1 shows microscopic images of Y_2O_3:Dy^{3+}phosphors under different magnifications. The images show irregular shape of the particles in the synthesized phosphors along with agglomeration which may be due to effect of high temperature synthesis [17].

3.1.2. EDXS analysis

EDXS is an important characterization technique to investigate the presence of starting elements in prepared powder samples. The EDXS spectrum of Y_2O_3: Dy^{3+} (1.5 mol %) shown in the Fig. 2.