Journal of Luminescence 133 (2013) 96–101

Contents lists available at SciVerse ScienceDirect

Journal of Luminescence

journal homepage: www.elsevier.com/locate/jlumin

Synthesis and characterization of nano Sr_2CeO_4 doped with Eu and Gd phosphor

K. Suresh [a,*], K.V.R. Murthy [d], Ch. Atchyutha Rao [b], N.V. Poornachandra Rao [c], B. Subba Rao [c]

[a] Department of Physics, CSR Sarma College, Ongole 523001, A.P., India
[b] Department of Physics, VRS & YRN College, Chirala 523157, A.P., India
[c] Department of Physics, VSR & NVR College, Tenali 522201, India
[d] Display Materials Laboratory, Applied Physics Department, Faculty of Technology and Engineering, The M.S. University of Baroda, Vadodara 390001, India

ARTICLE INFO

Available online 30 December 2011

Keywords:
Photoluminescence (PL)
Solid state reaction method (SSR)
Thermoluminescence (TL)
Compact fluorescent (CFL)

ABSTRACT

The present paper reports the synthesis and Photoluminescence (PL) studies of the Eu and Gd rare earth ions, co-doped in Sr_2CeO_4 phosphor at different concentrations within the range from 0.1 to 2 mol% using inorganic materials like Strontium Carbonate ($SrCO_3$), Cerium Oxide (CeO_2), Europium Oxide (Eu_2O_3) and Gadolinium Oxides (Gd_2O_3). The samples were prepared by the conventional solid-state reaction method, which is the most suitable for large-scale production. The received phosphor samples were characterized using XRD, SEM, PL, TL, FTIR and CIE techniques. Undoped Sr_2CeO_4 exhibits good photoluminescence emission due to the charge transfer (CT) mechanism. The PL emission mainly concentrates around 467 nm, when excited with 254, 260, 280 and 350 nm wavelengths. The Sr_2CeO_4 phosphor, when co-doped with Eu and Gd, the PL emission was observed from 350 to 650 nm range, sharp peaks around 467, 478, 491, 500, 511, 538, 557, 569, 587, 601 and 617 nm with high intensity. From the XRD data, using the Scherer's formula the calculated average crystallite size of undoped Sr_2CeO_4 is around 28 nm and co-doped with Eu, Gd is around 31 nm. Thermoluminescence (TL) studies were carried on all the phosphors under study. The present phosphor can act as single host for white light emission in compact fluorescent (CFL) and fluorescent lamps.

1. Introduction

Phosphor are used in cathode ray tubes (CRTs), projection televisions (PTVs), fluorescent tubes, X-ray detectors and field emission displays (FED) etc., [1]. Concerning many of these applications, the availability of systems consisting of uniform particles in size and shape [2] is also an essential prerequisite for improved performance, and new synthetic routes are been developed in order to reach these systems. This material has been found to exhibit luminescence under excitation with cathode and X-rays [3]. In addition, it has also been established that Sr_2CeO_4 exhibits photoluminescence under excitation with irradiation of ultraviolet rays [4–6]. Recently, a new promising blue phosphor, Sr_2CeO_4, was developed by combinatorial synthesis [7] and prepared by different routes. The luminescence associated with Eu contained in different host lattices has found applications related to its red light emission, which is important in the fields of displays, sensors and lasers. The past few decades have seen a lot of work reported on the use of divalent/trivalent Europium as a dopant in phosphors as they have very good optical properties (in the blue–red regions), which make them part of many display devices. Among all the rare-earth ions, Eu^{3+} is the most extensively studied, owing to the simplicity of its spectra and also its use in commercial red phosphors. The effect of co-doping of Gd on the PL emission/excitation was also studied.

In this study, we prepared Strontium Cerate phosphor (undoped Sr_2CeO_4 and Sr_2CeO_4:Eu:Gd) that exhibits broad excitation ranges of 240–350 nm using high temperature solid state reaction method. Furthermore, the photo luminescent properties of the powders resulting from variations of such synthesis conditions as temperature, activator concentration, were investigated. The characterization of the prepared materials was done using XRD, SEM, PL, TL, FTIR and CIE studies.

2. Experimental work

Strontium Carbonate ($SrCO_3$), Cerium Oxide (CeO_2), Europium Oxide (Eu_2O_3) and Gadolinium Oxide (Gd_2O_3) of high purity (99.9%) chemicals were used as starting materials to prepared Sr_2CeO_4 and Eu, Gd doped phosphor. Strontium carbonate ($SrCO_3$), Cerium Oxide (CeO_2) in stoichiometric proportions of

* Corresponding author. Tel.: +91 9502007506.
E-mail address: sureshkukkamalla@gmail.com (K. Suresh).

0022-2313/$ - see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.jlumin.2011.12.045

Sr:Ce as 2:1 is weighed and ground into a fine powder using agate mortar and pestle. The grounded samples were placed in an alumina crucible and fired at 900, 1000, 1100 and 1200 °C for 3 h in a muffle furnace with a heating rate of 5 °C/min. The samples are allowed cool to room temperature in the same furnace for about 20 h. Rare earth ions Eu, Gd and Eu:Gd were doped and co-doped keeping Gd concentration at 0.5% and changing Eu concentration from 0.1, 0.5, 1, 1.5 and 2 mol%. Spectrofluorophotometer (SHIMADZU, RF-5301 PC) was used for PL studies. The 1200 °C fired samples show good PL. Therefore 1200 °C fired material was used for XRD studies using Rigaku-D/max 2500 using Cu Kα radiation. The microstructures of the samples were studied using a scanning electron microscopy (SEM) (XL 30 CP Philips). All the spectra were recorded at room temperature.

3. Results and discussion

3.1. XRD Study

The XRD pattern of undoped Sr_2CeO_4 and doped with Eu 0.5%, Gd 0.5% and Eu:Gd 0.5% are shown in Fig. 1. From the XRD pattern it was found that the prominent phase formed is Sr_2CeO_4, after the diffraction peaks are well indexed based on the JCPDS no. 50-0115. This reveals that the structure of Sr_2CeO_4 is orthorhombic and is in agreement with the findings of the previous workers like Sankar et al. [6], Danielson et al. [7] and Chen et al. [8]. However the data reported by Jiang et al. [9] and Serra et al. [10] indicate triclinic structure.

The crystallite size was calculated using the Scherrer equation $D=k\lambda/\beta\cos\theta$, where k the constant (0.94), λ the wavelength of the X-ray (0.154 nm or 1.54 Å), β the full-width at half maxima (FWHM) and θ the Bragg angle of the XRD peak (1,1,1). The calculated average crystallite size of undoped Sr_2CeO_4 is ~28 nm. However the calculated average crystal size of sol gel synthesized Sr_2CeO_4 phosphor is of about 45 nm and of SSR prepared phosphor is about 155 nm by Ghildiyal et al. [11].

From Fig. 1 it is found the diffraction peaks are same for all the phosphors, which conclude that the dopant did not affect the host structure except change of the peak intensities. The calculated average crystallite size of Eu (0.5%) doped is ~31 nm, Gd (0.5%) doped is ~23 nm and Eu:Gd (0.5%) doped is ~31 nm.

3.2. SEM study

Fig. 2 shows the SEM micrograph of the undoped Sr_2CeO_4 phosphor, which appears like a flower. This may be due to the

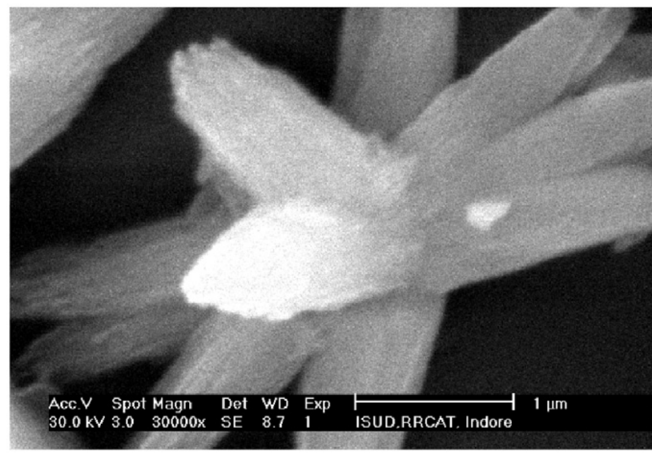

Fig. 2. SEM image of Sr_2CeO_4:Eu:Gd (0.5%).

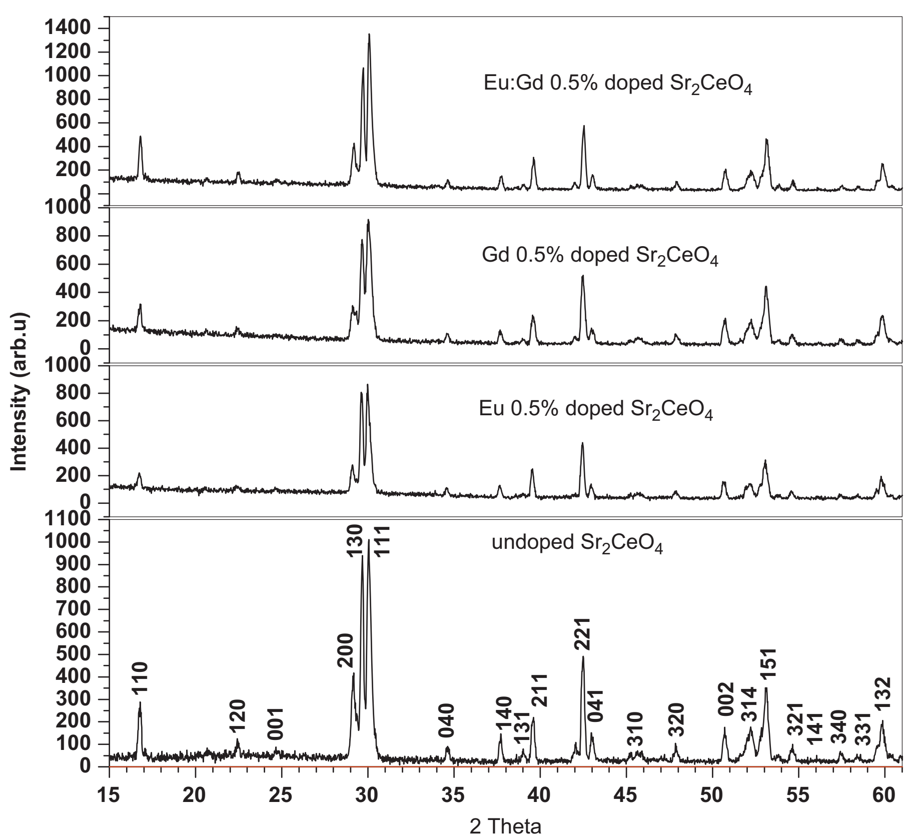

Fig. 1. XRD Pattern of Sr_2CeO_4, Sr_2CeO_4:Eu (0.5%), Sr_2CeO_4:Gd (0.5%) and Sr_2CeO_4:Eu:Gd (0.5%).