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Blue Emission from Cerium Doped Strontium Yttrium Oxide Phosphor

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Abstract— *The behaviour displayed by photoluminescence spectra of strontium yttrium oxide phosphor doped with cerium at variable concentration of Ce^{3+} (0.1 – 2.5mol %) ion. Phosphor was prepared by solid state reaction method with calcination temperature 1000^0C and sintering temperature 1350^0C in air atmosphere. Photoluminescence spectra of prepared phosphor shows the variation with cerium concentration and it shows well resolved peak at 406nm excited with 396nm xenon lamp. The PL spectrum is due to transition of cerium ion in host matrix. PL intensity increases with increasing the concentration of cerium and it maximum for 2mol% of Ce^{3+} ion, after that PL intensity decreases due to concentration quenching. Spectrophotometric determinations of peaks are evaluated by Commission Internationale de I'Eclairage (CIE) technique. The prepared phosphor is useful for display devices applications for blue emission.*

Keywords— *Blue emission; CIE coordinate; strontium yttrium oxide phosphor*

1. INTRODUCTION

In recent years, practical application in optical devices, such as color display, optical data storage, biomedical diagnostics and temperature sensors have been produced on the basis of rare earth ion doped materials [1, 2]. Recently, the luminescence properties of rare earth ions in SrY_2O_4 have attracted much attention. SrY_2O_4 belongs to the ordered $CaFe_2O_4$ structure, which is composed of a $(R_2O_4)2-$ (R = rare earth metal) framework of double octahedral with rare earth ions residing within the framework. Due to the thermal and chemical stability, SrY_2O_4 have been used in thermal barrier coating (TBC) materials [3, 4]. It has been found that SrY_2O_4: Eu^{3+} is one of promising red phosphors for Field Emission Display (FED) application [5–9].

SrY_2O_4 crystallizes in the $CaFe_2O_4$ structure, with two non-equivalent Y sites [5]. Both Y sites are coordinated by six oxygen atoms and both have Cs symmetry. The Y(1) site is nearly octahedral, while the Y(2) site is in a more distorted coordination environment. These sites are shown in Fig. 1, and bond-length data are summarized in Table 1. The Sr site in this host is eight-coordinate and also has Cs symmetry [10-23].

1.1 Experimental

To prepare SrY_2O_4 with various concentrations of cerium (0.1 mol% to 2.5 mol%), stoichiometric amounts of reactant mixture is taken in alumina crucible and is fired in air at 1000^oC for 2 hour in a muffle furnace. The Ce^{3+} activated SrY_2O_4phosphor was prepared via high temperature modified solid state diffusion. The starting materials $SrCO_3$, Y_2O_3, Ce_2O_3 and H_3BO_3 (as a flux) in molar ratio (0.1% to 2.5% of Ce) were used to prepare the phosphor. The mixture of reagents were grounded together for 45minute to obtain a homogeneous powder. Powder was transferred to alumina crucible, and then heated in a muffle furnace at 1350 °C for 3 hr [16-30]. The phosphor materials were cooled to room temperature naturally.

The samples were characterized by using Photoluminescence (PL), and HRTEM. The photoluminescence (PL) emission and excitation spectra were recorded at room temperature by use of a Shimadzu RF-5301 PC spectrofluorophotometer [30-33].

1.2 Results and Discussion

The images revealed that the Ce^{3+} doped SrY_2O_4 powder was a collection of nanorods 25-36 nm long and 1-2 nm thick. The synthesised sample showed the nanorod shapes, with no critical difference in morphology, this pattern is quite similar recorded by FEGSEM image [38]. The nano-rod formation is responsible for the very good PL spectra from prepared phosphor [38].

Under excitation wavelength of 396 nm (figure 2), the emission spectrum of synthesized SrY_2O_4:Ce^{3+} with variable concentration of Ce^{3+} (0.1 – 2.5mol%) phosphor shows a broad emission band extending in blue region from 406 nm (figure 3) with the maximum intensity at 406 nm, which is attributed to the electron transition from the 5d lowest energy level of Ce^{3+} to the $^2F_{5/2}$ to $^2F_{7/2}$ manifolds split by spin-orbit coupling [14, 15]. The broadness of the emission peak is ascribed to emission

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from more than one energy level. In the PL spectra which shows linear response with concentration up to 2mol% of Ce^{3+} after that concentration quenching occurs (figure 3) and the luminescence intensity decreases with increasing the Ce^{3+} concentration [16-17].

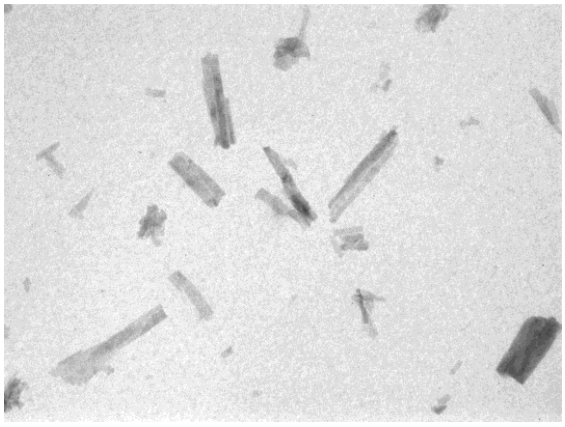

Fig. 1. TEM image of prepared phosphor

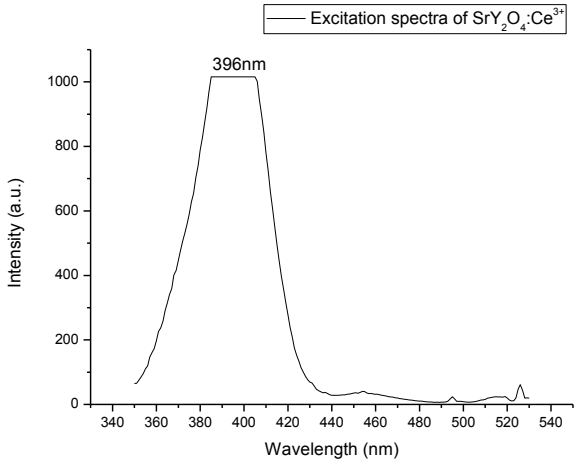

Fig. 2. PL excitation spectra of $SrY_2O_4:Ce^{3+}$ phosphor

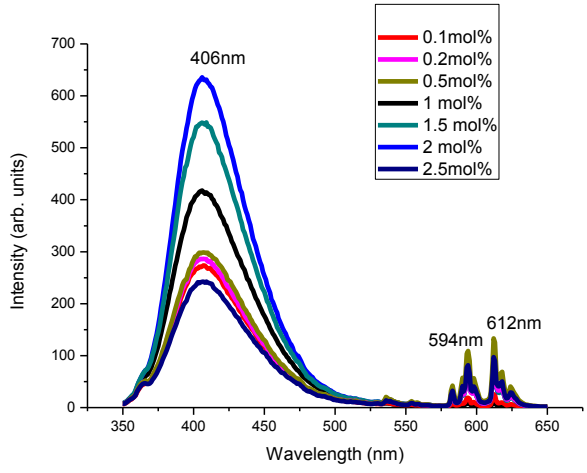

Fig. 3. PL emission spectra of $SrY_2O_4:Ce^{3+}$ phosphor

The emission peak centred at ~406 nm (blue region) was attributed to radiative recombination of photo-generated hole with an electron occupying surface defects namely the oxygen vacancies, F-centres (oxygen ion vacancy occupied by two electrons)/F-centres (oxygen ion vacancy occupied by single electrons)/surface states [18-20].

Commission Internationale de I'Eclairage (CIE) chromaticity coordinate for Ce^{3+} doped SrY_2O_4 phosphor were calculated using the blue LED with the excitation at 396nm as shown in figure 4 and the values are found in blue region. Their corresponding location has been marked in figure 4with cross in blue region. This clearly shows SrY_2O_4 sample doped with cerium can be used for blue light emitting applications and its chromaticity coordinate is x = 0.164, y = 0.026.The results indicate that $SrY_2O_4:Ce^{3+}$ (2%) phosphors can be selected as a potential candidate for LED (Light Emitting Diode) application. However, the relative intensity of the emission bandswhich provide the fundamental colours balance for blue -light emission was achieved with the 2mol% sample with the spectrum (Figure 4) providing the CIE 1931 chromaticity.

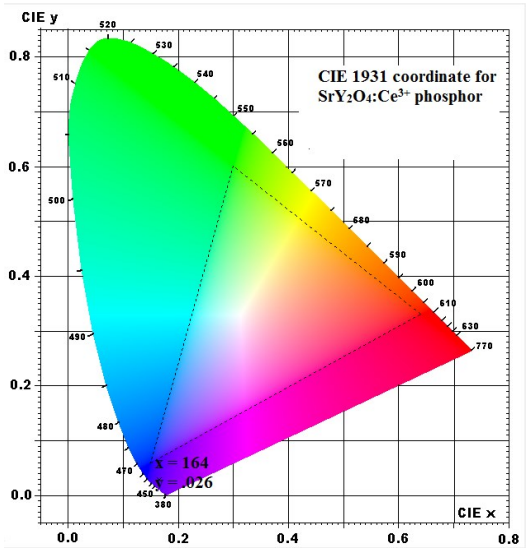

Fig. 4. CIE 1931 coordinate for $SrY_2O_4:Ce^{3+}$ phosphor (2mol% of cerium)

2. CONCLUSION

It is concluded from above study cerium doped sample for variable concentration was prepared by solid state reaction method more suitable for large scale production. For the variable concentration of cerium PL emission was observed and shows broad emission peak centered at 406nm (blue emission). Present phosphor can act as a host for blue light emission in display devices. The CIE of $SrY_2O_4:Ce^{3+}$ exhibit blue light, and its chromaticity coordinate is x = 0.164 and y = 0.026. The chromaticity point is in the deep blue region, indicating its high color purity.

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