Luminescence behaviour on rare earth doped phosphor for white light emitting diode

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Abstract: - The present paper reports the synthesis, characterization and luminescence behaviour of rare earth doped phosphor which is applicable in white light emitting diode (WLED) application. The phosphor was synthesized by solid state reaction method. This method is suitable for large scale production and less time taking from other methods. The rare earth ion Eu^{3+} used as a dopant and SrY_2O_4 phosphor used as a host material. The starting materials used for sample preparation are $SrCO_3$, Y_2O_3, Eu_2O_3 and H_3BO_3 using as a flux. Sample was characterized by Powder X-ray Diffraction technique (PXRD), and CIE techniques. Photoluminescence emission and excitation spectra recorded in room temperature. The broad excitation spectra found at 254nm and the emission spectra found all visible regions (400-650nm) which indicate that prepared sample used as WLED application which was verified by spectrophotometric determination (CIE) technique.

Keywords: Thermoluminescence; Photoluminescence; CIE; WLED.

I. 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].

II. EXPERIMENTAL:

To prepare SrY_2O_4 with europium (2mol%), stoichiometric amounts of reactant mixture is taken in alumina crucible and is fired in air at 1000°C for 2 hour in a muffle furnace. Every heating is followed by intermediate grinding using agate mortar and pestle. The Eu^{3+} activated SrY_2O_4 phosphor was prepared via high temperature modified solid state diffusion. The starting materials $SrCO_3$, Y_2O_3, Eu_2O_3 and H_3BO_3 (as a flux). 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 3hr [10]. The phosphor materials were cooled to room temperature naturally.

The samples were characterized by using Photoluminescence (PL), Thermoluminescence (TL), and XRD. The XRD measurements were carried out using Bruker D8 Advance X-ray diffractometer. The X-rays were produced using a sealed tube and the wavelength of X-ray was 0.154 nm (Cu K-alpha). The X-rays were detected using a fast counting detector based on Silicon strip technology (BrukerLynxEye detector). The photoluminescence (PL) emission and excitation spectra were recorded at room temperature by use of a Shimadzu RF-5301 PC spectrofluorophotometer. The excitation source was a xenon lamp [11-12].

III. RESULTS AND DISCUSSION:

The XRD pattern of the sample is shown in figure 2. The width of the peak increases as the size of the particle decreases. The size of the particle has been computed from the full width half maximum (FWHM) of the intense peak using Debye Scherer formula. Formula used for calculation is

$$D = \frac{0.9\lambda}{\beta \cos \theta}$$

Here D is particle size

β is FWHM (full width half maximum)

λ is the wavelength of X ray source

θ is angle of diffraction

D = 0.9*1.54/0.252*Cos (31.75) =32nm

For XRD pattern corresponding miller indices values are calculated which matches with JCPDS card no. 74-0264 as shown in Figure 1. Sample show orthorhombic structure.
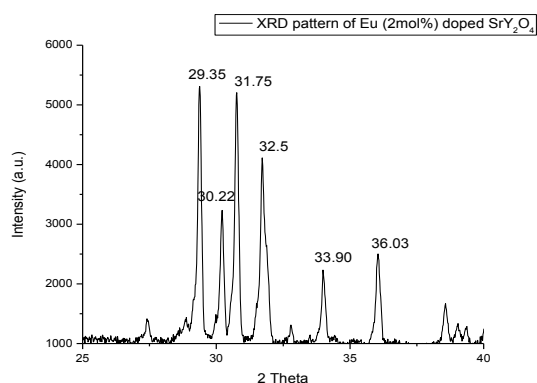

Figure 1 XRD pattern of SrY_2O_4:Euphosphor

IV. PHOTOLUMINESCENCE STUDY:

Broad excitation bands around 254 nm and 325 nmappeared at room-temperature excitation spectra ofSrY_2O_4:Eu^{3+}ismonitored at 400nm; respectively (Fig. 2&3).The band near 254 nm is known to be a charge transfer (CT) process that is related to the excitation of an electron from the oxygen 2p state to a Eu^{3+} 4f state [13]. Upon excitation with 254 nm and 325 nm UV light, both the emission spectra were described by the well known $^5D_0\rightarrow^7F_J$ (J=1, 2) line emissions of the Eu^{3+} ions with the strong emission for J=1 and J=2 at 594 nm and 615, 625 nm (Fig. 5(a)). The $^5D_0\rightarrow^7F_1$transition is purely magnetic dipole allowed and is usually taken as a reference transition because the crystal field does not considerably alter the intensity of this transition [14]. Appearance of five lines for the $^5D_0\rightarrow^7F_1$transition provided an evidence of two sites of Eu^{3+} ions(2J+1=3 for J=1). Due to the different valence states andthe different ion sizes between Sr^{2+} (113 pm) and Eu^{3+} (95pm), calcination temperature was not high enough for $Eu^{3+}$to substitute Sr^{2+} and the replacement of Eu^{3+} to Y^{3+} (89pm) happened. There are two sites of Y^{3+} ions with similardimension of O^{2-} polyhedron in SrY_2O_4 lattice, so the charge transfer is expected from the oxygen ions to thesubstituting Eu^{3+}. Similar splitting was observed to the$^5D_0\rightarrow^7F_2$transition, which is electric dipole forbidden,and sensitive to the ligand environment. Appearance oftwo excitation bands with monitored wavelengths of 615 nm and 625 nm also indicated that the Eu^{3+} ionsoccupied two Y^{3+} ions sites.The $^5D_0-^7F_0$ transition, which isboth, spin and electric dipole forbidden, and issensitive to the different lattice field, splits into twolines at 582 and 589 nm, revealing that theEu^{3+} at least occupied two sites.
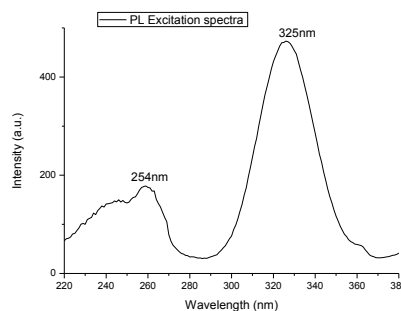

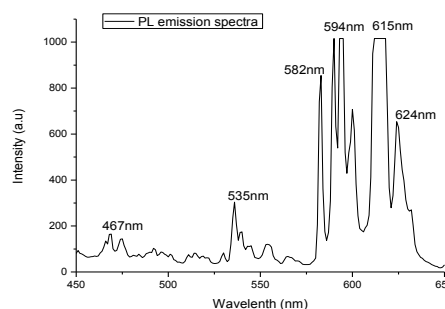Figure 2 PL excitation spectra monitored at 400nm excitation

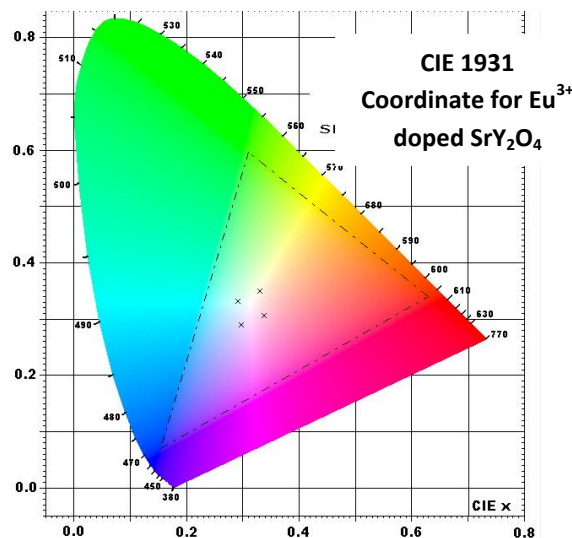Figure 3 PL emission spectra monitored at 325nm excitation

Figure 4 CIE 1931 coordinate for Eu doped phosphor

The CIE coordinates were calculated by Spectrophotometric method using the spectral energy distribution of the SrY_2O_4:Eu^{3+} sample (Fig 4). The color co-ordinates for the Eu doped sample are x=0.42 and y=0.32 (these coordinates are very near to the white light emission). Hence this phosphor having excellent color tenability from white light emission.

V. CONCLUSION:

SrY_2O_4:Eu^{3+} doped phosphor synthesised by modified solid state reaction method. XRD pattern confirms that synthesized sample shows orthorhombic structure. The

PL emission was observed in the range 405, 415, 469, 535, 594, 615 and 625nm for the SrY_2O_4 phosphor doped with Eu^{3+}. Excitation spectrum found at 254 and 325nm. Sharp peaks found around 593, 615 and 625nm with high intensity. The present phosphor can act as single host for white light emission in display devices. The CIE 1931 chromaticity coordinates much closer to the equal-energy white-light.

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