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Synthesis and Characterization of Samarium doped Sr_2CeO_4 Phosphor

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Abstract: Strontium cerium oxide Sr_2CeO_4 doped Sm^{3+} phosphor was synthesized by solid state reaction method at temperature 12000 C for 4h. The powder samples were characterized by X-ray diffraction (XRD), Scanning Electron microscope (SEM), the X-Ray diffraction pattern reveals the crystallite size and the structure is orthorhombic. Photoluminescence excitation and emission spectra of Sr_2CeO_4:Sm^{3+} (0.5mol %) are recorded at room temperature. The color co-ordinates for the Sr_2CeO_4:0.5 mol % Sm^{3+} were x =0 .6687 and y = 0.3311.This phosphor has a good potential for applications in display devices.

Keywords: *Photoluminescence; Solid state reaction method; Phosphor; nana particles.*

I. INTRODUCTION

The Rare earth materials have attracted much attention for their impressive applications in artificial light, X-ray medical radiography, lamps and display devices [1, 2]. The discovery and development of new phosphor materials is of great importance for the advance of flat panel display and illumination technology. Compared with organic materials and sulfide phosphors, oxide-based phosphors have the advantage: stable crystalline structure and high physical and chemical stability. Therefore, oxide-based phosphors, especially rare earth-based oxide phosphor are attracting more and more attention. It has been found that the luminescence materials with low-dimensional structures generally exhibit special luminescence properties. Sr_2CeO_4 consists of infinite edge-sharing CeO6 octahedral chains separated by Sr atoms. Luminescence originates from a ligand to metal Ce4+ charge transfer. The broad emission band of Sr_2CeO_4 blue phosphor 471 nm is suitable for the doping of rare earth ions in pursuing new luminescent materials. The rare earth materials exhibit excellent sharp- emission luminescence properties with suitable sensitization and effectively used in designing of white light emitting materials. [3, 4] In this paper, the formation process, micro-structure and luminescent properties of the synthesized Sr_2CeO_4: Sm^{3+} (0.5mol %) were investigated.

II. MATERIALS AND METHODS

Analytical grade Strontium nitrate [$Sr(NO_3)_2$],Cerium oxide (CeO_2), and Samarium Oxide(Sm_2O_3) of assay 99.9% were used as starting materials. All the phosphor samples are prepared via solid state reaction method (SSR). These materials were taken in Stoichiometric proportions of Sr: Ce as 2:1. $SrCO_3$ and CeO_2 with rare earth were weighed in molecular stoichiometry. These phosphor materials were ground in an agate mortar and pestle about an hour, grinded thoroughly to get fine powder. This phosphor powder was taken in alumina crucible. The samples were fired at 1200ºC for 3 hours with a heating rate of 4ºC/min in a muffle furnace by keeping in an alumina crucible closed with lid **[**5, 6]. The samples were kept at the set temperature for four hours then cooled down naturally. All samples were prepared by same technique.

The structural studies were carried out by X- ray diffraction technique in reflection mode with filtered Cu Kα radiation (λ = 1.54051 A^0) with Rigaku, D Max III VC, Japan. Raman spectra were recorded on Reni show In via Raman microscope. The FTIR spectrums were recorded on SHIMADZU IR Affinity-1 model transmission spectrometer with KBr pellet method over the range 400- 4000 cm-1 The photoluminescence spectra was recorded at room temperature using Spectrofluorophotometer (SHIMADZU, RF–5301 PC) using Xenon lamp as excitation source.

III. RESULTS AND DISCUSSION:

The typical X-ray diffraction pattern of the resultant Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor prepared via the solid state reaction method are shown in fig. 1. The X-ray diffraction patterns of Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphors sample were well consistent with the data indicated in JCPDS card No. 50-0115 and structure of Sr_2CeO_4 phosphor is orthorhombic. The calculated average crystallite size of the Sr_2CeO_4 phosphor is 22 nm [7]. When Samarium doped with Sr_2CeO_4 the crystallite size is increases which is 35nm.

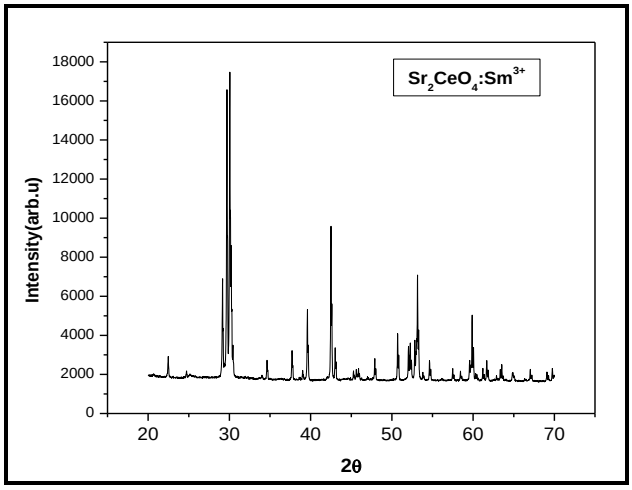

Figure 1: XRD Pattern of Sr_2CeO_4: Sm^{3+} Phosphor

As doping concentration increases from 0 to 0.5mol %, the crystallinity of Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor was decrease slightly with the increase in doping amount of Sm^{3+}. Samarium ions were doped to substitute strontium ions in the host lattice of Sr_2CeO_4 due to the similar ionic radius and electric charge[8]. However the difference of ionic radius of Sr^{2+} (For 6-coordination, ionic radius of Sm^{3+} (0.0958 nm) was

smaller than that of Sr^{2+} (0.118 nm), would lead to destroy the crystal structure of Sr_2CeO_4, resulting in the formation of $SrCeO_3$ and decrease in crystallinity of Sr_2CeO_4.

In order to study the morphology of the Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor, SEM analysis was carried out. Figure2. Shows the SEM photograph of Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor powder prepared via the solid state reaction method heating at 1200 ºC for 4h. From the results it is clear that the particles of Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor is in irregular shape and tightly agglomerated.

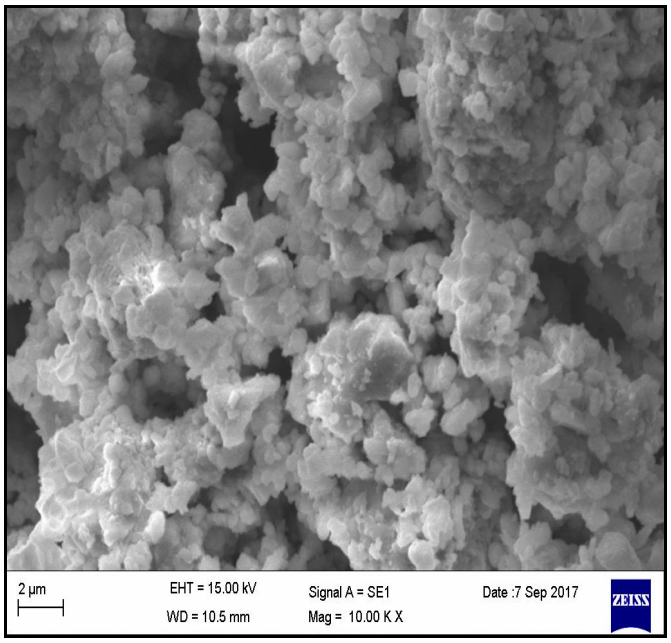

Figure 2. SEM of the Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor

A. Luminescent Properties

The excitation spectra of solid state reaction derived Sr_2CeO_4:Sm^{3+} (0.5 mol%) calcinated at 1200 ºC for 4h, as shown in figure 3. The excitation spectra is broad spectra from 220 to 400 nm and centered located at 356 nm. The broad band could be assigned to the legend to-metal charge transfer from O2- to Ce4+.

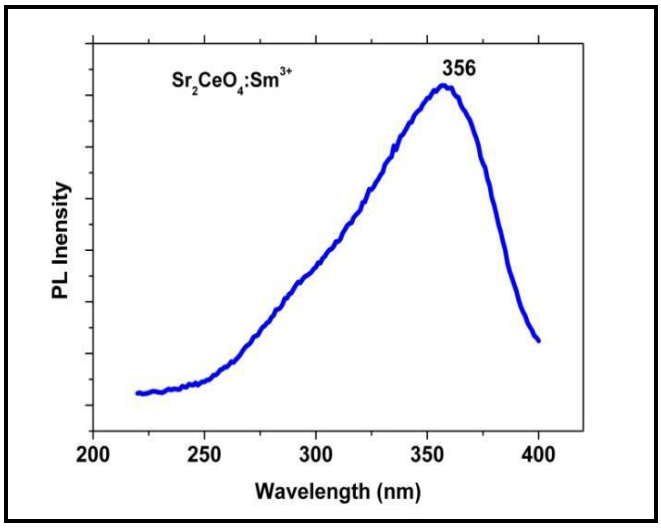

Figure.3: Excitation spectra of Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor

The emission bands in figure 6 can be attributed into two groups corresponding to different transition of Sm^{3+} [9, 10]. The emission peak at 568 nm corresponds to $^4G_{5/2} \rightarrow {}^6H_{5/2}$, transition, 611nm corresponds to $^4G_{5/2} \rightarrow {}^6H_{7/2}$ transition and the transition 653 nm corresponds to $^4G_{5/2} \rightarrow {}^6H_{9/2}$, the strongest emission peak located at 611 nm showing prominent and red light is due to the $^4G_{5/2} \rightarrow {}^6H_{7/2}$ magnetic dipole transition of Sm^{3+}.

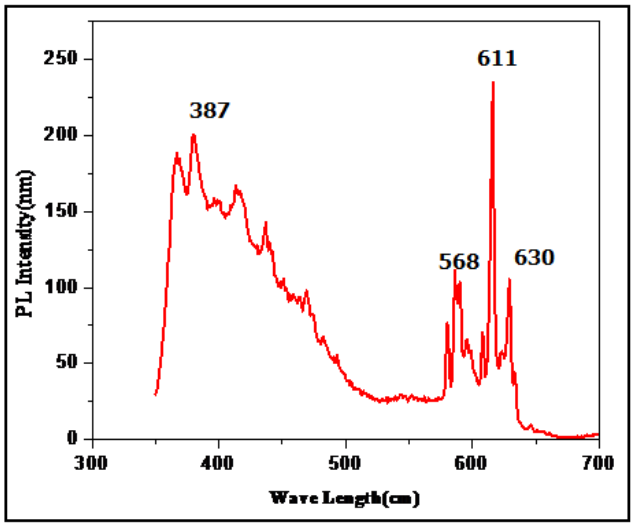

Figure 4: Emission spectra of Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor

To study the effect of trivalent samarium doping and to see the effect of the same on the emission characteristics of the host, photoluminescence spectra were recorded at room temperature for the Sr_2CeO_4: Sm^{3+} (0.5mol %) phosphor as shown in figure. 4 Under excitation with 320 nm wavelength the emission spectra shows the broad Ce^{4+}- O^{2-} charge transfer band in the blue region superimposed with the Sm^{3+} emission lines in the yellow and red region. These spectral features are characteristic of intra-configurationally f-f transitions of the RE ions. Because tetravalent cerium in Sr_2CeO_4 has no 4f electrons, emissions are due to the presence of Sm3+ having five 4f electrons. But on increasing the samarium concentration the sharp lines of the samarium emission appear prominently and the Ce^{4+}- O^{2-} CT transitions of the host decreases relatively. The narrow lines are assigned to the transitions from the between 4G5/2 excited state to the lower 6HJ (J = 5/2, 7/2 and 9/2) energy levels of the ground multiplets of Sm^{3+}. According to the selection rules [10-11] magnetic dipole transitions that obey J = 0 and ±1 (J = total angular momentum) are allowed for Sm^{3+} in a site with inversion symmetry. The emission spectra for the Sr_2CeO_4sample were peaking at the 387nm but when doped with samarium, the emission spectra are dominated by the red 4G5/2→6H7/2 transition centered at 611nm. Additional emission were observed at the 568 and 653nm ascribed to the 4G5/2→6H5/2 and 4G5/2→6H9/2 transitions, respectively.

The emission spectra shows broad Ce^{4+}- O^{2-} CT emission band in the blue-green region superimposed with the Sm^{3+} emission lines in the yellow and orange-red regions[12,13]. It is further observed from the emission spectra of Sr_2CeO_4: Sm^{3+} (0.5mol %) Phosphor, that as the samarium concentration increases, the photoluminescence intensity at 387nm goes on decreasing but the intensity at 568nm and 611nm shows an increase for Samarium (0.5mol%) concentrations.

B. CIE Co-ordinates

Most lighting specifications refer to colour in terms of the 1931 CIE chromatic colour coordinates which recognize that the human visual system uses three primary colours: red,

green, and blue. The dominant wavelength is the single monochromatic wavelength that appears to have the same colour as the light source. The dominant wavelength can be determined by drawing a straight line from one of the CIE white illuminants (Cs (0.3101, 0.3162)), through the (x, y) coordinates to be measured, until the line intersects the outer locus of points along the spectral edge of the 1931 CIE chromatic diagram [14-18].

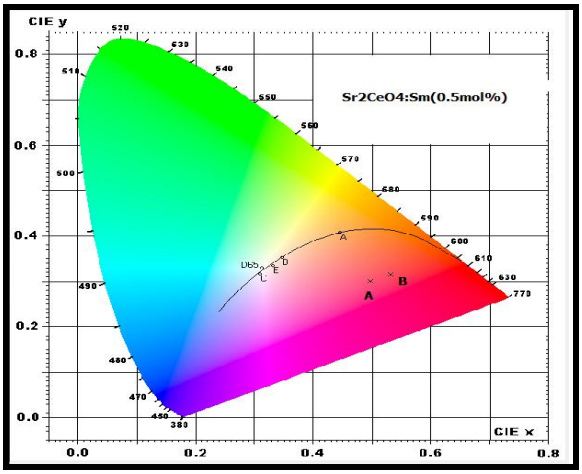

Figure 5: CIE co-ordinates for un-doped and Sr_2CeO_4: Sm^{3+} (0.5mol %) Phosphor

The colour co-ordinates for (A) the pure Sr_2CeO_4were x = 0.1515 and y = 0.1674 and (B) Sm, doped Sr_2CeO_4 phosphors were x=0.6687 and y=0.3311. Figure.5 illustrates the CIE chromaticity diagram for the emissions of pure and Sm^{3+} (0.05mol %) doped Sr_2CeO_4. This phosphor having colour tenability from orange to slightly move to red and it has good potential application for technological in the lighting system.

CONCLUSION

Sr_2CeO_4:Sm^{3+} (0.5mol %) phosphor was successfully synthesized by solid state reaction method. The XRD study confirms that the Sm^{3+} doped Sr_2CeO_4 compound has orthorhombic structure at room temperature. The average crystallite size of the trivalent Samarium doped with Sr_2CeO_4 the crystallite size is 35nm. The emission peaks at 568nm corresponds to 4G5/2 → 6H5/2, 611nm corresponds to 4G5/2 → 6H7/2 and the transition 653nm corresponds to 4G5/2 → 6H9/2, the strongest emission peak located at 611 nm showing prominent and red light is due to the 4G5/2 → 6H7/2 transition of Sm^{3+}. The color co-ordinates for Sr_2CeO_4: Sm^{3+} (0.5 mol %) were x = 0.6687 and y = 0.3311. Solid state reaction method proved to be very promising for the controlled preparation of phosphor material, with an even better CIE chromacity index than reported previously. The result shows this phosphor has potential application in the field of emission devices.

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