

Synthesis, Characterizations And Luminescence Study of Erbium Doped Sr₂CeO₄ Nano Phosphor.

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Abstract. Sr₂CeO₄: Er³⁺ phosphor was synthesized by high temperature Solid state reaction method. Using oxides as a raw materials and Erbium was used as an activator. XRD, SEM, EDAX and Photoluminescence spectra were used to investigate the formation process, microstructure and luminescence properties of the synthesized phosphor. The result shows orthorhombic structure and average crystallite size is 47 nm. The excitation spectrum of Sr₂CeO₄ phosphor displays broad spectra with two peaks around 262nm and 399 nm. The excitation spectra of Sr₂CeO₄: Er³⁺ phosphor display broad band with two peaks the former peak is stronger than the latter one, this broad band is due to the charge transfer band of the Ce⁴⁺ ion. The emission spectrum of Sr₂CeO₄ phosphor shows broad band spectra with peak around 470nm with the excitation by a radiation of 262nm. The emission of Sr₂CeO₄: Er³⁺ for the excitation 262nm was emits bluish Green light and the emission spectra shows a broad band with peaks around at 470, 527 535,552 and 558 nm.

Keywords: Photoluminescence, solid state reaction method, XRD, SEM, Phosphor.

INTRODUCTION

The research for oxide phosphors has been increasing due to their applications in many fields, such as cathode ray tubes (CRTs), light-emitting diodes (LEDs) and field emission displays (FEDs). Rare earth applications in the field of display devices still a hot topic much of the research around the globe is to improve the phosphor efficiency and to enhance the luminescence properties of the phosphor with discovery of blue light emitting Sr₂CeO₄ by combinatorial chemistry method in 1998 by Danielson [1]. Sr₂CeO₄ consist of infinite edge-shearing CeO₆ octahedral chains separated by Sr atoms [2]. The luminescence originates from a ligand-to metal Ce⁴⁺ charge transfer [1]. The broad emission band is suitable for the doping of rare earth ions in pursuing new luminescent materials. The blue phosphors are very few and if a suitable blue phosphor is found then it can be added to the well studied red and green combination for white light emission from the phosphor. If blue phosphor Sr₂CeO₄ doped with trivalent rare earths europium and samarium emit in the red region of the visible spectra [5]. The rare earth materials exhibit excellent sharp- emission luminescence properties with suitable sensitization and

effectively used in designing of white light emitting materials. Solid state lighting have a very bright future in various lighting applications because of their high energy efficiency and cost effectiveness compared to incandescent bulbs.

MATERIALS AND METHODS

For the synthesis of Sr₂CeO₄ doped with erbium solid state reaction method was used. The starting materials were strontium carbonate SrCO₃, cerium oxide CeO₂, and erbium Oxide Er₂O₃ supplied by National Chemicals, Baroda, (Gujarat State) of 99.9 % purity. These materials were taken in Stoichiometric proportions of Sr: Ce as 2:1. SrCO₃ and CeO₂ with rare earth are weighed in molecular stoichiometry. These all materials were ground in an agate mortar and pestle, grinded thoroughly to get fine powder. This powder was taken in alumina crucible. After closing the cover the crucible was loaded in furnace and heated to the temperature 1200⁰ C at the rate of 300⁰ C/hr. The samples was kept at the set temperature for four hours then cooled down naturally. All samples were prepared by same technique.

CHARACTERIZATIONS

The powder X-ray diffractograms (XRDs) of the compounds were recorded using an automated Rigaku Miniflex X-ray diffractometer (D Max III VC, Japan). The observed (hkl) reflections and their intensities were compared with the calculated ones generated using the computer program POWD (an Interactive Powder Diffraction Data Interpretation and Indexing Program, Version 2.2). Photoluminescence excitation and emission spectra were recorded at room temperature using Spectrofluorophotometer (SHIMADZU, RF – 5301 PC) equipped with a 150 W Xenon lamp as excitation source

RESULTS AND DISCUSSION

The structure and phase purity of the Sr_2CeO_4 phosphor and Sr_2CeO_4 doped Erbium the concentration (1.5 mol%) synthesized by solid state method was investigated by X-ray diffraction method.

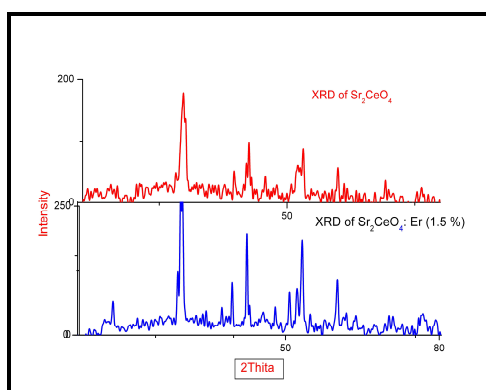


Figure 1 XRD of Sr_2CeO_4 and $\text{Sr}_2\text{CeO}_4:\text{Er}$

Results are shown in Fig. 1 for the pure Sr_2CeO_4 and for $\text{Sr}_2\text{CeO}_4:\text{Er}$ (1.5%). Measurements were made from $2\theta = 10^\circ$ to 80° with steps of 0.02° . The crystallite size of the particles of powder samples were calculated using Scherrer equation

$$d = 0.9\lambda / \beta \cdot \cos\theta,$$

where β represents the full width at half maximum (FWHM) of XRD lines. The average crystallite size of the Sr_2CeO_4 phosphor is 22 nm. When Er doped with Sr_2CeO_4 the crystallite size is 35 nm. The computer program POWD (an Interactive Powder Diffraction Data Interpretation and Indexing Program, Version 2.2) was used to calculate lattice parameters. The XRD patterns of the powders revealed that the structure of Sr_2CeO_4 is orthorhombic having lattice parameters $a = 6.1200\text{ \AA}$, $b = 10.3600\text{ \AA}$, $c = 3.5900\text{ \AA}$ and cell volume $V = 227.62\text{ (\AA}^3\text{)}$, which agrees with the findings of previous research work of Danielson et al [1], Sankar et al [10].

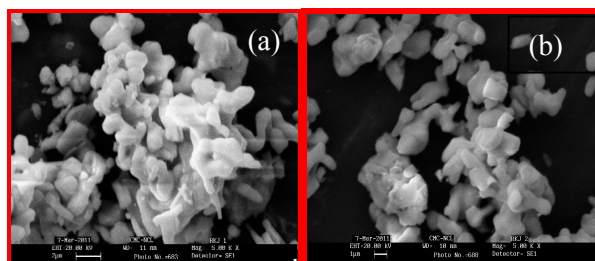


Figure 2 SEM Image of (a) Sr_2CeO_4 and (b) $\text{Sr}_2\text{CeO}_4:\text{Er}$ (1.5%)

Fig.2 (a) Shows the SEM micrograph of pure Sr_2CeO_4 of and Fig. 2 (b) shows SEM micrograph of particles of $\text{Sr}_2\text{CeO}_4:\text{Er}$ (1.5 which is appears to irregular shape having an average basal diameter of 550 nm and a length of 1.5 μm and only a few particles are loosely agglomerated

An elemental analysis was carried out for Strontium Cerate (Sr_2CeO_4) doped Erbium (Er) by employing the energy dispersive X-ray analysis technique which provides local information of the concentrations of different elements in phosphor.

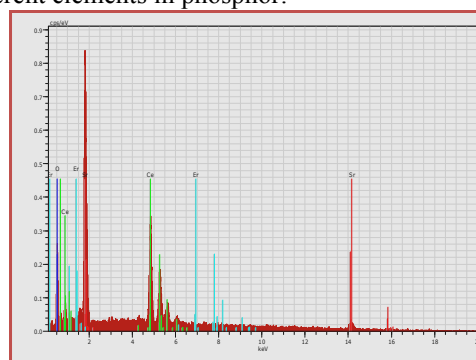


Fig- 3 EDAX spectra of $\text{Sr}_2\text{CeO}_4:\text{Er}$

Fig- 3 shows the EDX spectra of $\text{Sr}_2\text{CeO}_4:\text{Er}$ in which the presence of Sr, Ce, O and Er are clearly identified.

The excitation spectra of the Sr_2CeO_4 and $\text{Sr}_2\text{CeO}_4:\text{Er}$ shown in fig. 4. The excitation spectrum of Sr_2CeO_4 shows two peaks around 262 nm and 399 nm latter stronger than former these two excitation peaks may be related to different $\text{Ce}^{4+} - \text{O}^{2-}$ distances in the lattice [4,7]. These two excitation peaks are attributed to the different charge transfer transitions. The excitation spectrum of $\text{Sr}_2\text{CeO}_4:\text{Er}$ shows two peaks around 262 nm and 362 nm and former stronger than the latter. The emission spectra for pure Sr_2CeO_4 when excitation wavelength is 262 nm the emission peak is at 470 nm shows broad band due to $f \rightarrow t_{ig}$ transition of Ce^{4+} perfect blue region with very good intensity [9]. However the effect of Er dopant modified the emission of Sr_2CeO_4 phosphor and the intensity was slightly decreased.

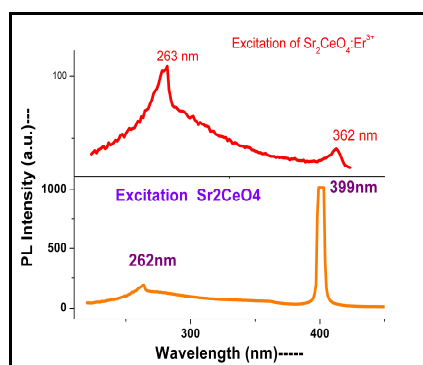


Figure 4 Excitation spectra for Sr_2CeO_4 and for $\text{Sr}_2\text{CeO}_4:\text{Er}$

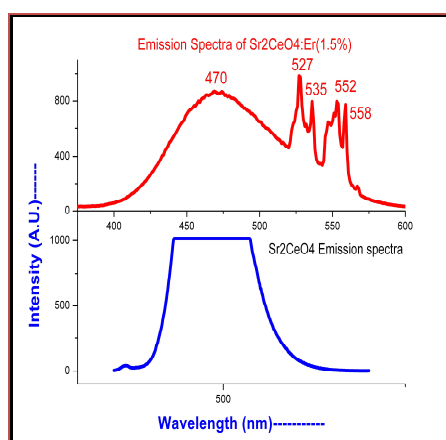


Figure 5 PL Emission Spectra of Sr_2CeO_4 and $\text{Sr}_2\text{CeO}_4:\text{Er}$ (1.5%)

The emission spectra of samples with Erbium doping (1.5 %) is shown in figure 5. The Emission spectrum of $\text{Sr}_2\text{CeO}_4:\text{Er}^{3+}$ recorded on excitation with wavelength 262 nm in the spectral region 390 – 650 nm at room temperature. The spectrum is quite similar to the reported Er^{3+} doped glass [14-15]. By exciting the erbium doped Sr_2CeO_4 at $\lambda_{\text{exc}} = 262$ nm four transitions such as ${}^2\text{H}_{9/2} \rightarrow {}^4\text{I}_{15/2}$, ${}^4\text{F}_{3/2} \rightarrow {}^4\text{I}_{15/2}$, ${}^2\text{H}_{11/2} \rightarrow {}^4\text{I}_{15/2}$ and ${}^4\text{S}_{3/2} \rightarrow {}^4\text{I}_{15/2}$ was observed corresponding to the band position at 527, 536, 554 and 559 nm respectively. The ${}^2\text{H}_{9/2} \rightarrow {}^4\text{I}_{15/2}$ transition intensity is found to be high as compared to the other transitions when the concentration of Er^{3+} is 1.5 % in the host matrix. If concentration of Er^{3+} is gradually increased the intensity of ${}^2\text{H}_{9/2} \rightarrow {}^4\text{I}_{15/2}$ transition also gradually increased.

CONCLUSIONS

- The XRD pattern confirms the formation of Sr_2CeO_4 compound in single phase and. The average grain size of the Sr_2CeO_4 phosphor is 22

nm. And when Er doped with Sr_2CeO_4 the grain size is 35 nm.

- EDX spectra of $\text{Sr}_2\text{CeO}_4:\text{Er}$ in which the presence of Sr, Ce, O and Er are clearly identified.
- PL emission of pure Sr_2CeO_4 phosphor was observed at 470 nm which is blue emission this conform the formation of nano blue phosphor to good PL. and $\text{Sr}_2\text{CeO}_4:\text{Er}$ was observed when the excitation of the samples was kept at 262nm,
- The emission is in Bluish green color. The phosphor $\text{Sr}_2\text{CeO}_4:\text{Er}$ (1.5%) shows good Photoluminescence, Intensity may be useful in various source lighting applications.

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