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# Effect of Erbium doping on the structural and photoluminescent properties of $Sr_2CeO_4$ Blue Nano Phosphor

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## ABSTRACT

*The present paper reports the morphology and spectroscopic study of blue emitting $Sr_2CeO_4$ phosphor doped with the rare earth element Erbium (1.0 %) was synthesized by Solid state reaction method. The powders were fired at $1200^0$ C for four hour. The photoluminescence study of these materials reveals the emission in the bluish green region. The X-Ray diffraction pattern reveals the grain size of particle. The materials were conforming from EDAX and the morphological study of material gives from SEM.*

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

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## INTRODUCTION

Inorganic compounds doped with rare earth ions form important class of phosphors as they possess a few interesting characteristics such as excellent chemical stability, high luminescence efficiency and flexible emission colors with different activators [1]. The popularity of oxide based luminescent materials is due to the facts that they exhibits superior photoluminescence and Cathodoluminescence properties which makes them useful as important components of color emission in field emission display (FED), plasma display panel (PDP) and lamps [2]. Rare earth applications in the field of display devices is 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 $Sr_2CeO_4$ by combinatorial chemistry method in 1998 by Danielson [3]. $Sr_2CeO_4$ consist of infinite edge-shearing $CeO_6$ octahedra chains separated by Sr atoms [2]. The luminescence originates from a ligand-to metal $Ce^{4+}$ 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 $Sr_2CeO_4$ 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.

## MATERIALS AND METHODS

For the synthesis of $Sr_2CeO_4$ doped with Erbium solid state reaction method was used. The starting materials were Strontium Carbonate $SrCO_3$, Cerium Oxide $CeO_2$, and Erbium Oxide $Er_2O_3$ supplied by National Chemicals, Baroda, (Gujarat State) of 99.9 % purity. These materials were taken in Stoichometric proportions of Sr: Ce as 2:1. $SrCO_3$ and $CeO_2$ 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 $1200^0$ C ate the rate of $300^0$ C/hr. The samples was kept at the set temperature for four hours then cooled down naturally. All samples were prepared by same technique.

Scanning Electron Microscopy (SEM), EDX and XRD was taken from NCL Pune. The photoluminescence spectra were recorded at room temperature using Spectroflurophotometer (SHIMADZU, RF – 5301 PC) using Xenon lamp as excitation source at Display research Lab. Department of Applied Physics, M. S. U. Baroda.

## RESULTS AND DISCUSSIONS

### X- RAY diffraction (XRD)

The structure and phase purity of the $Sr_2CeO_4$ phosphor and $Sr_2CeO_4$ doped with Erbium the concentration (1.0 %) synthesized by solid state method was investigated by X-Ray Diffraction Method. Results are shown in Fig. 1 and 2 for the pure $Sr_2CeO_4$ and for $Sr_2CeO_4$: Er (1.0%). All diffraction patterns were obtained using CuKα radiation (λ = 1.54051 A°), at 30 kV and 15 mA.

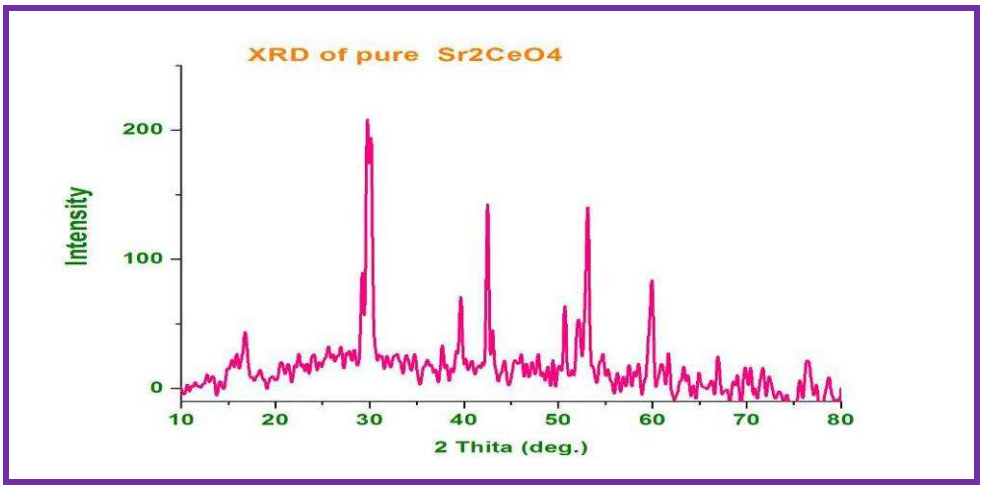


**Figure 1 XRD Pattern of $Sr_2CeO_4$**

Measurements were made from 2θ = 10° to 80° with steps of 0.02°. The XRD patterns of the powders revealed that the structure of $Sr_2CeO_4$ is Orthorhombic, when crystallites are less than

approximately 100nm in size appreciable broadening in the X-ray diffraction lines occurs [8]. The grain size of the particles of powder samples were calculated using Scherrer equation

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

where β represents the full width at half maximum (FWHM) of XRD lines. 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.

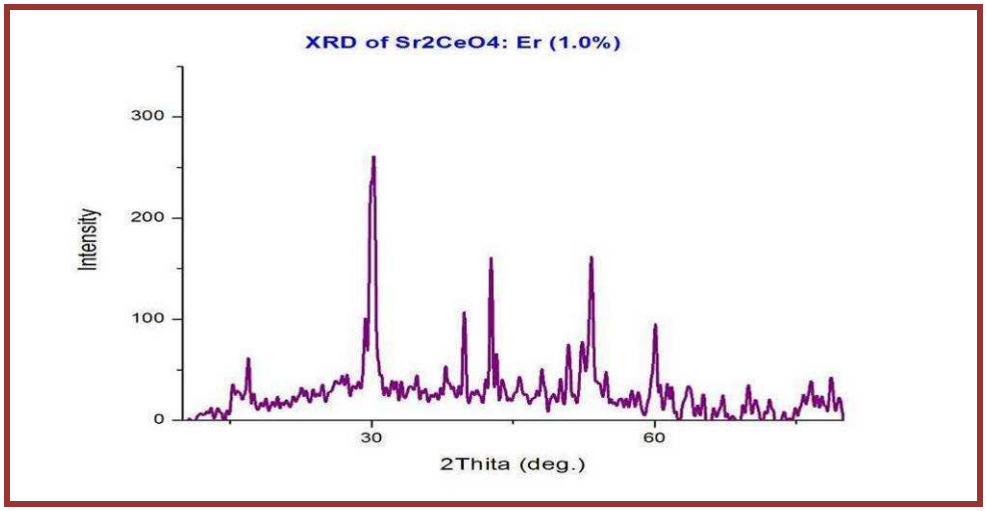


**Figure 2 XRD Pattern of $Sr_2CeO_4$: Er (1.0%)**

**Scanning Electron Microscope (SEM)**

Fig.3 Shows the SEM image of pure $Sr_2CeO_4$ sintered at $1200^0$ C for four hrs, and in figure 4 shows SEM image of $Sr_2CeO_4$: Er (1.0%) which is appears to irregular shape having an average basal diameter of 550 nm and a length of 1.5 µm.

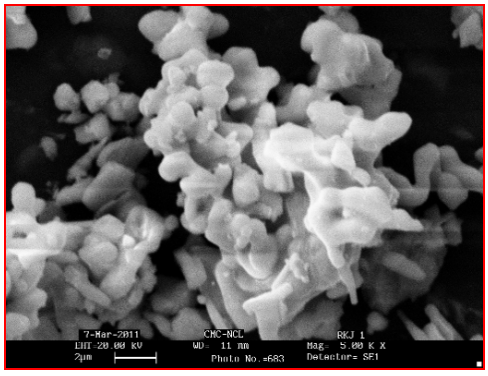

**Figure 3 SEM Image of $Sr_2CeO_4$**

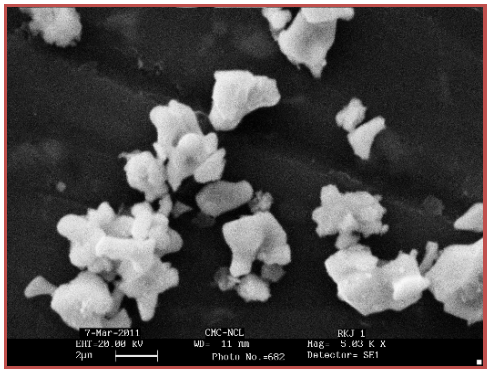

**Figure 4 SEM Image of $Sr_2CeO_4$: Er (1.0%)**

**Energy Dispersive X-RAY Analysis (EDAX)**

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- 5 shows the EDX spectra of $Sr_2CeO_4$: Er in which the presence of Sr, Ce, O and Er are clearly identified from table 1 the spectral data, it can be visualized that the compound is found to be virgin and possesses high purity [14].

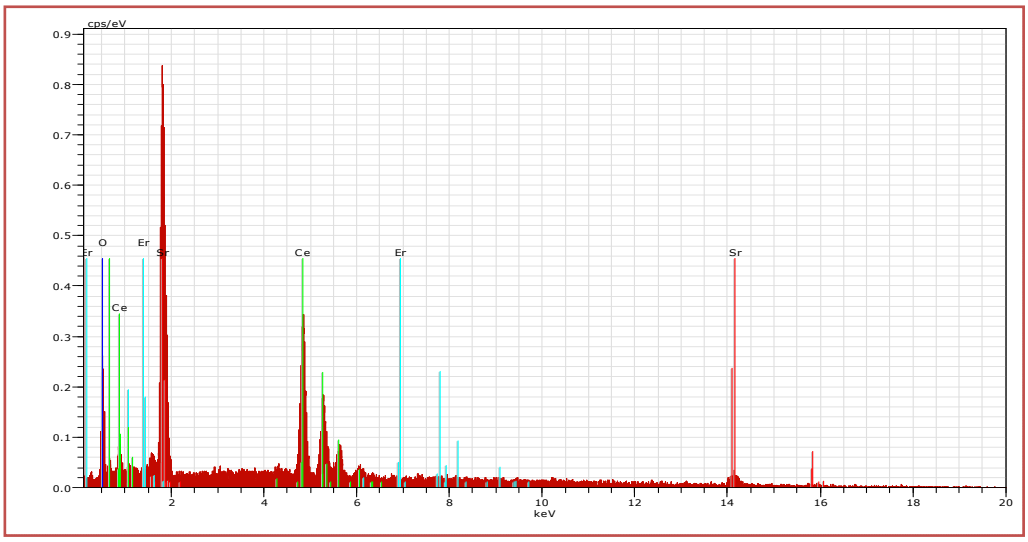


**Fig- 5 EDAX spectra of $Sr_2CeO_4$: Er**

| Elements | Net counts | C norm. Weight % | C Atom. Weight % |
|---|---|---|---|
| Sr | 38 | 43.50 | 35.87 |
| Ce | 58 | 39.50 | 20.37 |
| O | 8 | 8.92 | 40.27 |
| Er | 68 | 8.08 | 3.49 |
| Total: | | 100.00 | 100.00 |

**Table 1: Quantitative Results of $Sr_2CeO_4$: Er**

## PHOTOLUMINESCENCE STUDY (PL)

The PL excitation spectra of the $Sr_2CeO_4$ and $Sr_2CeO_4$ doped with erbium prepared by solid state reaction method are shown in fig. 6 and 7 respectively. The emission spectra for pure $Sr_2CeO_4$ when excitation wavelength is 262 nm the emission peak is at 470 nm a perfect blue region with very good intensity shown in fig.8. However the effect of Er dopent modified the emission of $Sr_2CeO_4$ phosphor and the intensity was slightly decreased. The emission spectra of samples with Erbium doping (1 %) is shown in figure 9. When the excitation of the samples was kept at 262nm, the emission peaks appeared at 470, 527 and 554nm. It is interesting to note that the emissions are in bluish green region.

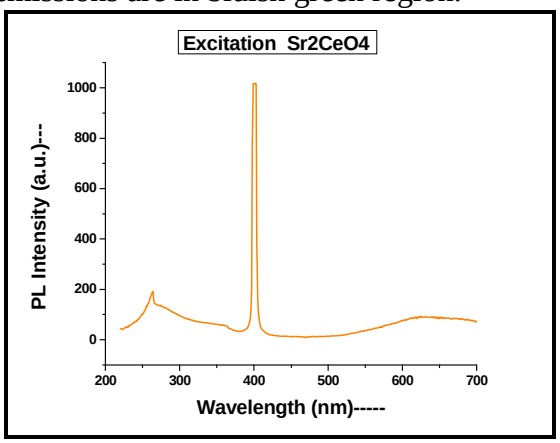


**Figure 6 Excitation spectra for $Sr_2CeO_4$**

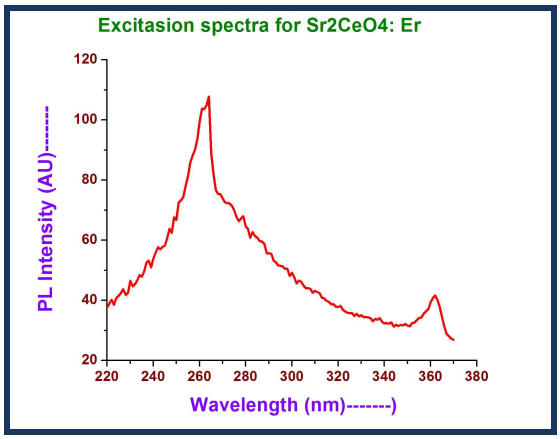


**Figure 7 Excitation Spectra of $Sr_2CeO_4$: Er**

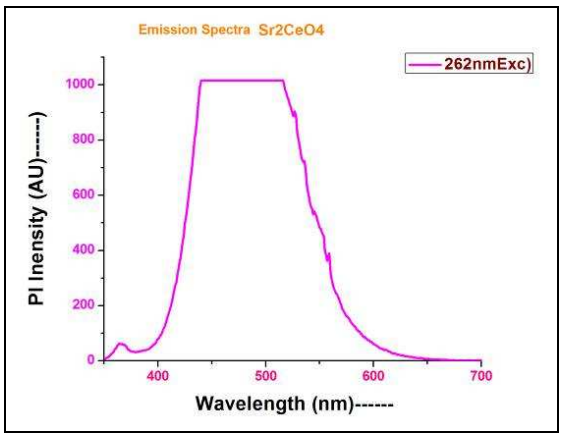


**Figure 8 PL Emission Spectra of $Sr_2CeO_4$**

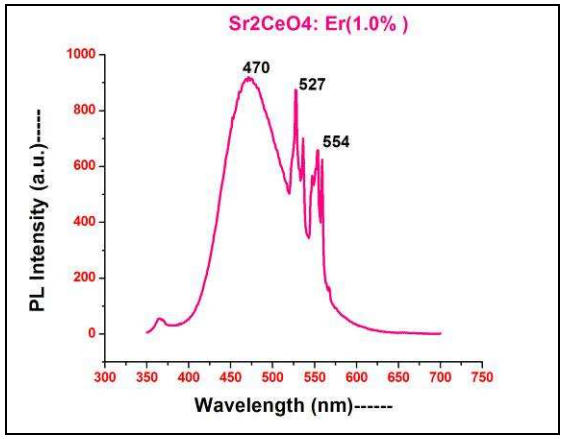


**Figure 9 PL emission of $Sr_2CeO_4$: Er (1.0 %)**

## CONCLUSION

The XRD pattern confirms the formation of majority 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 $Sr_2CeO_4$: 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 $Sr_2CeO_4$: Er was observed when the excitation of the samples was kept at 262nm, the emission peaks appeared at 470, 527 and 554 nm. The emission is in Bluish green color. The phosphor $Sr_2CeO_4$ doped with Er (1.0%) shows good Photoluminescence, Intensity may be useful in various source lighting applications.

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