Synthesis and Characterization of Sr_2CeO_4 Phosphor Doped with Erbium

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Abstract

The present paper reports the Photoluminescence (PL) of the Sr_2CeO_4 phosphor, singly doped with Erbium rare-earth ion with different concentrations (0.01, 0.1, 0.2, 0.5 and 1%).The phosphor samples were synthesized using the standard solid state reaction technique. The effect of Er dopant on the structural, morphological, and Photoluminescent properties of the samples are studied with X-ray diffraction (XRD), PL and SEM analysis. The PL emission of undoped Sr_2CeO_4 phosphor was observed at 470 nm with high intensity followed by the primary Er emissions with good intensity at 525, 530, 549, 557 and 565 nm.

Introduction

The phosphor research has taken a great shape and the need of the hour is to revolutionize the synthesis technique and modify it according to the needs today. Solid state reaction has been used as a very common technique to develop phosphor either at laboratory level or commercial level, but there is a remarkable shift in the paradigm with the advent of nanotechnology which is now driving the industry forward towards an unknown and unprecedented phase, where the small is gaining and the big losing literally. Nanometer sized phosphor powders exhibit good spectroscopic properties that are different from their micrometer sized counter parts. Generally, the observed luminescence in nano crystalline materials has been explained using two arguments: (i) luminescence is dominated by quantum confinement effects and (ii) luminescence is dominated by defect interactions and chemical species. For the last one and half decade the nanotechnology, with size limitation of less than 100 nm, has been moving at a pace and gaining momentum, research in this field is becoming more and more active [1-5]. In this regard the phosphor research has also awakened to the challenge and new and better materials with the size limitations are being pursued rigorously. A number of publications have appeared on the same and the effect on the size with the effect on the optical property has been a topic of great interest today. The goal of this research effort was to develop a comprehensive understanding of the factors that affect the luminescence behavior and study the optical properties of synthesized nano crystal phosphors with crystallite sizes less than 100 nm [6-9].

Experimental Details

The samples were synthesized by standard solid state reaction technique. To prepare Sr_2CeO_4 host phosphor, the starting chemicals, strontium nitrate and cerium nitrate of purity of 99.9% were taken in appropriate stiochiometry of 2:1. The metal nitrates and Urea in an appropriate molar ratio were weighed, mixed and grounded using agate mortar and pestle for 1 hour to make fine powder. The

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samples were heated at 1200°C for 3 hours using muffle furnace with a heating rate of 4°C/min. The same procedure was followed to prepare Er (0.5%) doped Sr_2CeO_4 phosphor. The photoluminescence spectra were recorded at room temperature using Spectrofluorophotometer (JOBIN VYON, Fluoromax-3), XRD using Synchrotron Beam line and SEM analysis using XL 30 CP Philips, studies are done on the prepared samples.

Results and Discussion

XRD Analysis

The crystalline structure of the powders was analyzed by X-ray powder diffraction (XRD). The diffractometer used was an Angle Dispersive X-ray Diffraction (ADXRD) beam line No. 12 with λ = 0.895 Å. Figure-1 shows the XRD data for one of the samples studied in this work Sr_2CeO_4: Er (0.5%) sintered at 1200°C for 3 hours. The crystalline phases were identified with the International Centre for Diffraction Data (ICDD) database card number 89-5546. All the diffraction peaks were well indexed and confirms the Sr_2CeO_4 single phase. It clearly indicates that the heat treatment temperature and time were sufficient to form single phase.The crystallite size was determined using using Scherer's formula $D = k\lambda/\beta\cos\theta$, where k the constant (0.94), λ the wavelength of the X-ray (0.895 Å), β the full-width at half maxima (FWHM) and θ the Bragg angle of the XRD big peak. The average crystallite size was calculated using Scherer's formula is 70Å or ~7 nm.

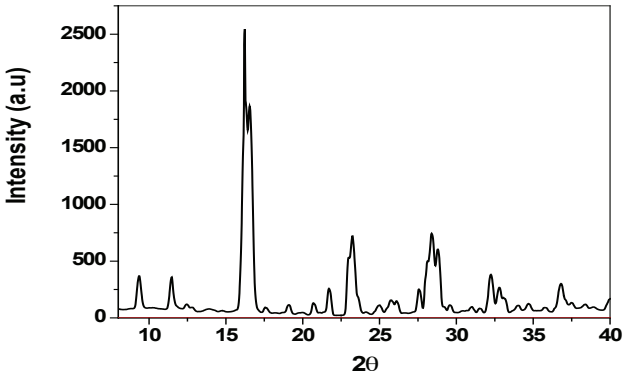

Fig.1. Powder XRD pattern of Sr_2CeO_4: Er (0.5%)

SEM Analysis

Figure- 2 shows the SEM image, the flower shape which can be seen. This may be due to the formation of a fractal attributed to sort of self organization. Length of each petal is around 1μm originated from the central cluster with a diameter of around 350 nm ends with 100 nm. SEM is interesting this type of formation may be due to the flux used in the synthesis of the phosphor material.

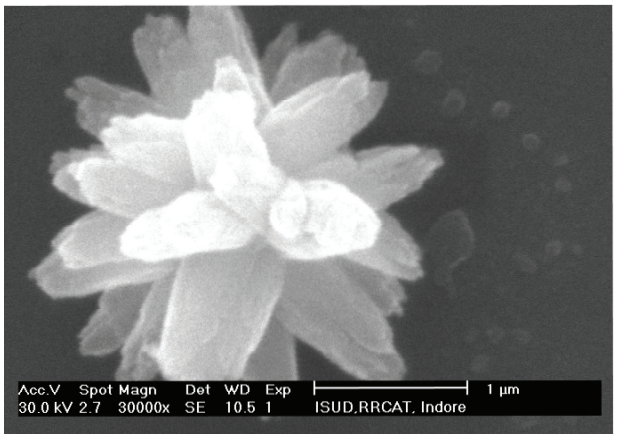

Fig. 2. SEM image of Sr2CeO4: Er (0.5%)

Photoluminescence Analysis

Figure-3a shows the PL excitation spectrum of Er (0.5%) doped Sr_2CeO_4 phosphor monitored under 470nm wavelength shows peaks at 260, 280 and 350nm, the intense broad band is attributed may be due to the charge – transfer (CT) transition between Ce^{4+}– O^{2-} as described by Danielson et al [9]. We studied the corresponding emission spectra of both Sr_2CeO_4 host phosphor and Er doped Sr_2CeO_4 phosphor under 350 nm excitation wavelength [9].

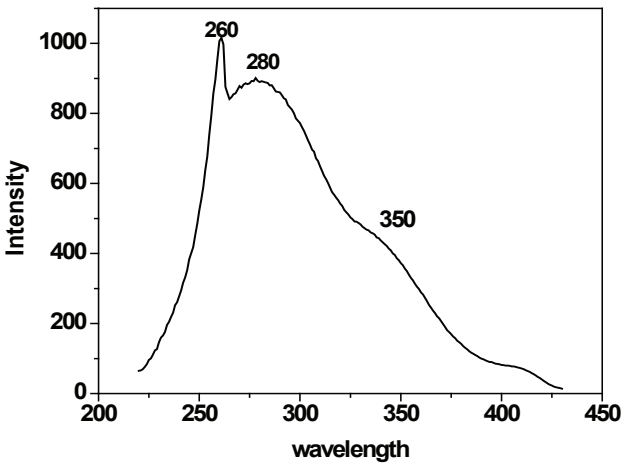

Fig. 3a. Shows the PL excitation spectrum of Er (0.5%) doped Sr_2CeO_4 phosphor monitored under 470 nm wavelength

Figure-3b&c shows the PL emission spectrum of undoped Sr_2CeO_4 and Er (0.5%) doped Sr_2CeO_4 phosphor under the excition of 350 nm wavelength. PL emission mainly concentrates around 467nm followed by the primary Er emissions with good intensity bands centered at 525, 530, 549, 557 and 565nm. It is interesting to note the emission is bluish green. The transitions are 2H11/2→4I15/1, 2H11/2→4I15/2, 4S3/2→4I15/2, 4S3/2→4I15/3 and 4S3/2→4I15/4 respectively [10-14].

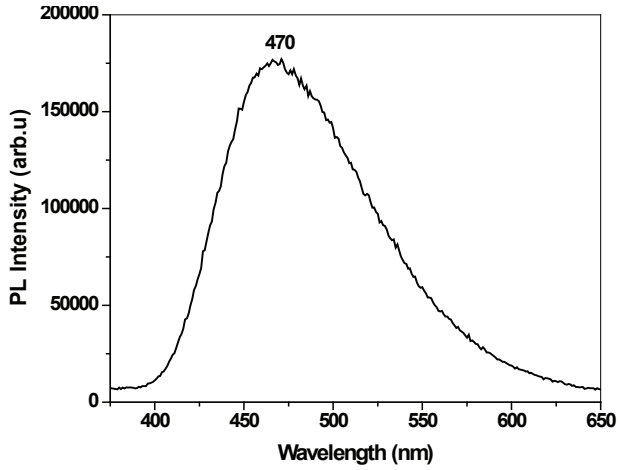

Fig. 3b. Shows the PL emission spectrum of undoped Sr_2CeO_4 phosphor when excited with 350 nm wavelength

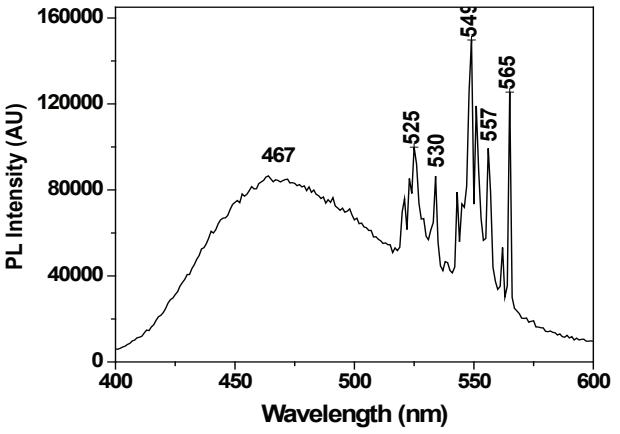

Fig. 3c. Shows the PL emission spectrum of Er (0.5%) doped Sr_2CeO_4 phosphor when excited with 350 nm wavelength

Conclusion

The crystallite size calculated using shearers formula is 57 nm this confirms the formation of nano phosphor. PL emission spectrum of Er (0.5%) doped Sr_2CeO_4 phosphor when excited with 350 nm emits good bluish green color. The present studied phosphor can be considered as compact fluorescent lamps (CFLs) phosphor for decorative lamps.

Acknowledgement

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