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Photoluminescence Study of Rare Earth Doped Nano Sr_2CeO_4 Phosphor

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Abstract

Photoluminescence (PL) studies of undoped Sr_2CeO_4 blue nano phosphor and doped with La, Eu and Dy rare earth ions of 0.5% concentration in Sr_2CeO_4 phosphor samples are reported in the present paper. All the samples were prepared through standard solid state reaction method. All the required chemicals were weighted for molar concentration and thoroughly mixed in agate mortar and pestle. The final mixture was heated at 1200 ºC for 3 hour. The received sintered material is a hard cake and looks as light cream colour. The XRD study reviles the formation of nano particles (~ 9nm). The PL was recorded with 250nm excitation and the PL emission was observed at 470 for pure specimen and for doped with Dy the PL emission was reduced to 10%. When doped with La and Eu the PL emission was mainly concentrated at 470 with many allowed emission peaks of La and Eu. From this study it can be inferred the solid state reaction method is adequate for synthesis of Sr_2CeO_4 nano particles.

Keywords: *photoluminescence; solid state reaction method; Phosphor; nano particles.*

1. INTRODUCTION

At present, we are living in a transition period toward flat panel displays, and CRTs are being more and more replaced by other technologies, in particular, liquid crystal displays (LCDs) and plasma display panels (PDPs). The most promising technology for screen sizes larger than 40 inch is the PDP. Satisfactorily produced red and green commercial materials many researchers, but comparable materials for the blue emission are still lacking and are under development for practical applications. Even in the paper industry, fluorescent dyes that absorb UV and emit in blue color are widely used as organic optical brightening agents (OBA) and new inorganic ones have been under investigation. Concerning many of these applications, such as FED and OBA, the availability of phosphor systems consisting of uniform particles in size and shape is also an essential prerequisite for improved performance, and new synthetic routes are been developed in order to reach these systems. Recently, a new promising blue phosphor, Sr_2CeO_4, was developed by combinatorial synthesis and prepared by different routes, such as conventional solid state reaction, chemical co-precipitation, microwave calcinations, pulsed laser deposition, polymeric precursors and ultrasonic spray pyrolysis method [1-4]. In this work, fine particles of the undoped blue Sr_2CeO_4 phosphor doped with La, Eu and Dy rare earth ions are prepared via solid state reaction method and spectroscopic study on all the samples are reported.

2. MATERIALS AND METHOD

Analytical grade Strontium nitrate [$Sr(NO_3)_2$], Cerium oxide (CeO_2), Lanthanum oxide (La_2O_3), Europium oxide (Eu_2O_3) and Dysprosium oxide (Dy_2O_3) of assay 99.9% were used as starting materials. All the phosphor samples are prepared via solid state reaction method (SSR).

First we prepared undoped Sr_2CeO_4 phosphor by weighing, mixing inorganic salts, Strontium nitrate

[$Sr(NO_3)_2$], Cerium oxide (CeO_2) in 2:1 molar ratio. We ground into fine powder using agate mortar and pestle about an hour. The samples were fired at 1200 ºC for 3 hours with a heating rate of 4^oC/min in a muffle furnace by keeping in an alumina crucible [5, 6]. In the same way La, Eu and Dy rare earth ions doped in Sr_2CeO_4 phosphor concentration (0.5 mol %)

All the phosphor samples were characterized by X-ray diffractometry using (Synchrotron Beam line), Particle size analysis was done using, laser particle size analyzer Malvern Instrument Ltd (U.K) and Photoluminescence studies using (SHIMADZU RF5301 PC), recorded at room temperature.

3. RESULTS AND DISCUSSION

3.1 Physical properties

After heating at 1200^0C and cooling to room temperature in the furnace, the samples appear light cream in colour and hard crystalline material was received. All the samples were again ground using agate motor and pestle to make uniform powder.

3.2 X-ray Diffractometry (XRD)

XRD of the present material were done on Indus beam line at RRCAT Indore. The wave length of ($0.89A^o$).Fig.1 is the XRD pattern of undoped Sr_2CeO_4 phosphor. On comparison with literature most of the peaks are matching and the majority of the material in single phase and is well agreement with the findings of the previous workers like Chia-Hao-Hsu et. al. [7]. The calculated crystallite size using Scherer's formula (t =K.λ\Bcosθ) for undoped Sr_2CeO_4 is around ~ 9nm. This confirms the formation of nano phosphor, via solid state method [8].

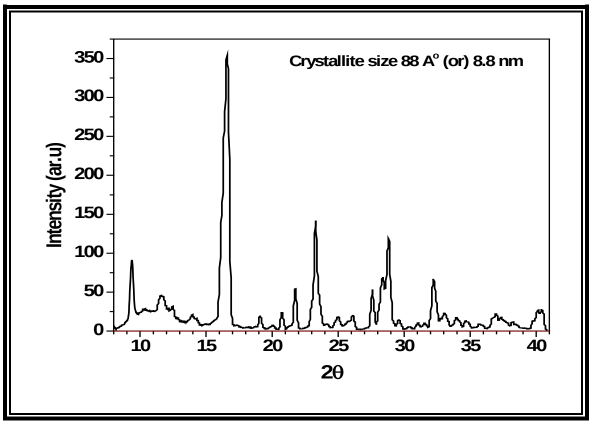

Fig.1: XRD Pattern of Sr_2CeO_4

3.3 Particle size Analysis

The prepared phosphor specimen particle size was measured by using laser based system Malvern Instrument U.K as shown in the fig. The mean diameter of the particle size as follows. Sr_2CeO_4:26µm, La: 18.31µm, Eu: 17µm, Dy: 32µm from the above data the average particle diameter of Europium doped phosphor is 17 µm and the crystallite size is around 9nm.As such many particles agglomerate and from as a crystallite many crystallite together becomes a particle approximately 2000 crystallites (9 nm) together forms a particle of diameter is 17µm in Eu doped Sr_2CeO_4.

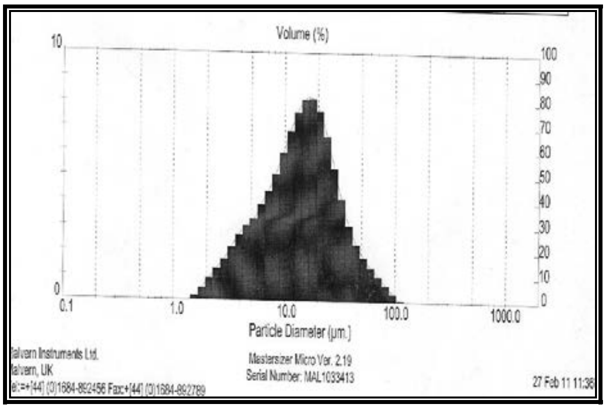

Fig.2 undoped Sr_2CeO_4

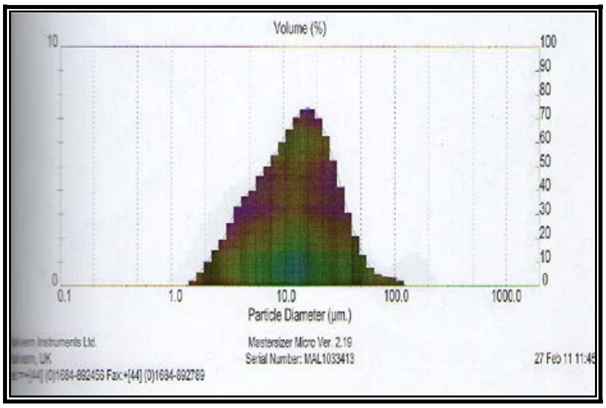

Fig.3 Eu doped Sr_2CeO_4

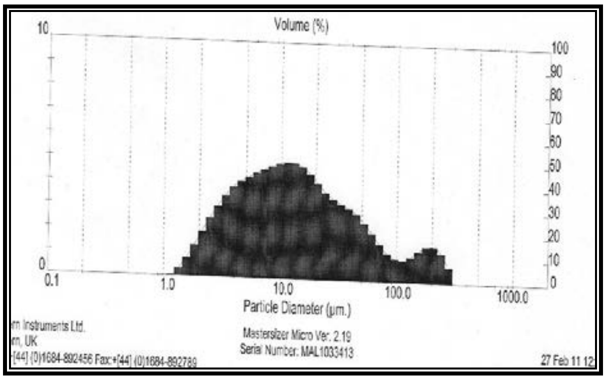

Fig.4 Dy doped Sr_2CeO_4

3.3 Photoluminescence Study

Fig.5 shows PL emission spectrum of undoped Sr_2CeO_4 phosphor, it is observed that under 250nm excitation, phosphor shows broad emission from 350 –

650 peaking at 470nm. This broad band is due to f→t_1g transitions of Ce^{4+}. When excitation was varied, the observed emission is same but intensity is high for 260nm excitation only. Here we observed the crystal field around 370nm wavelength with high intensity, when compared with the pervious works.

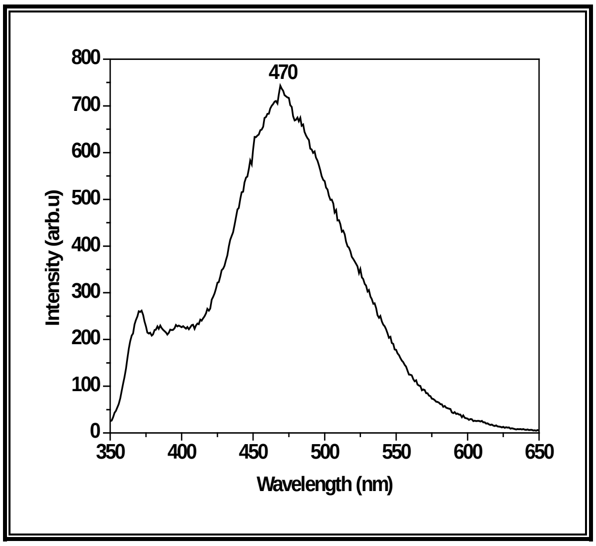

Fig.5: Emission Spectrum of undoped Sr_2CeO_4 at 250nm excitation

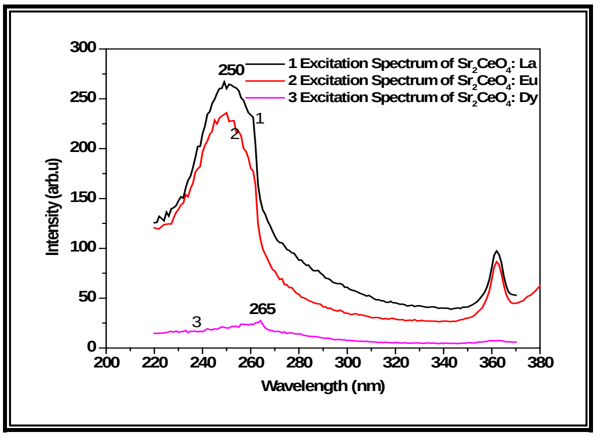

Fig.6: Excitation Spectrums of La, Eu & Dy (0.5%) doped Sr_2CeO_4

Fig.7 shows the PL emission of Eu and Dy rare earth ions doped keeping Dy 0.5% concentration at constant, varying the Eu concentrations from 0.01 -1% a shown in the fig.7 in Sr_2CeO_4 phosphor. Under 270nm excitation, we observed that when La is doped the emission spectrum is same as undoped Sr_2CeO_4 phosphor along with same crystal field which is not shown in the fig. In the case of Eu we observed that, all the transitions of Eu ion are not observed at 0.01 and 0.1 concentrations, whereas the Dy peak at 575nm is well resolved with high intensity. When the Eu concentration increases further the peaks are resolving well, consequently the fall of 575nm peak of Dy ion is observed. Finally concluded that at higher concentrations of Eu ion the emission, red color dominates.

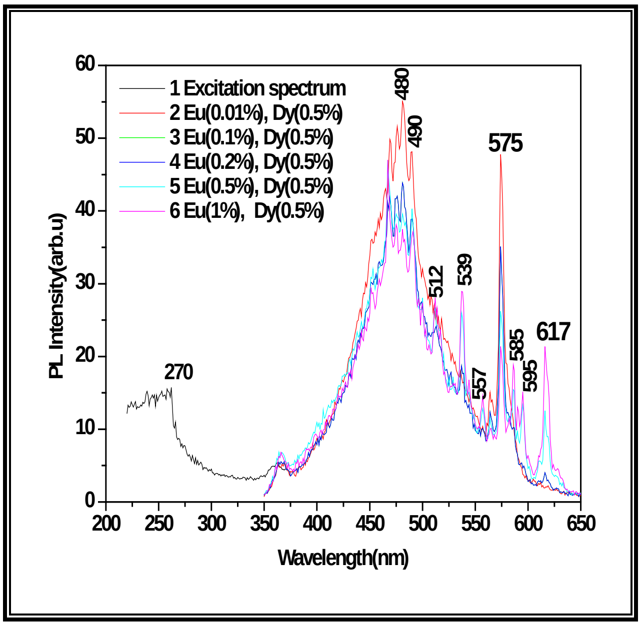

Fig.7: Emission Spectrum of Eu (0.01, 0.1, 0.2, 0.5 &1%) & Dy (0.5%) doped Sr_2CeO_4 under 270nm excitation

Where as Dy ion shows 470 & 575nm emission peaks (curve 1), without showing crystal field. We also observed the emission spectra under different concentrations and at different excitations. Overall the samples shows emission intensity is high at 0.01% concentration under 260nm excitation wavelength.

4. CONCLUSIONS

The present phosphor under study can be a good material for many display devices. The calculated average crystallite size using Scherer's formula is ~9nm. This confirms the formation of nano phosphor with good PL intensity under 270nm excitation.

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