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Synthesis and Characterization of Sr_2CeO_4 Phosphor doped with Eu

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Abstract
The photoluminescence (PL) spectra of Sr_2CeO_4 doped with Eu^{3+} ions of different concentrations (0.1%, 0.5%, 1.0%, 1.5%, and 2.0%) are reported. The blue emission powder phosphor Sr_2CeO_4 has been synthesized using a conventional solid state reaction method. The powders were characterized by means of X-ray diffraction and scanning electron microscopy. The photoluminescence spectra were recorded at room temperature under different excitations, of Sr_2CeO_4 shows broad emission peak observed at 467nm and emission peaks of $Sr_2CeO_4:Eu^{3+}$ of different concentrations were observed around 467, 490, 512, 537, 556, 587 and 616nm. Emission intensity is high for Eu (0.5%) under 280nm excitation. From XRD data by using the Scherer's formula the calculated mean crystallite size of Sr_2CeO_4 and Eu (0.5%) doped Sr_2CeO_4 is 28, 31nm respectively. From this preparing nano size Sr_2CeO_4 phosphor using SSR technique is possible than other techniques like sol-gel etc.

Keywords: Ceramics, Chemical synthesis, X-ray diffraction, Photoluminescence

1. Introduction

The search for blue phosphor emitters has been increasing due to their applicability in many fields, such as cathode ray tubes (CRTs), projection televisions (PTVs), fluorescent tubes, X-ray detectors and field emission displays (FED) [1]. 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[2]. Concerning many of these applications, the availability of systems consisting of uniform particles in size and shape[3] 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[4] and prepared by different routes. This material has been found to exhibit luminescence under excitation with cathode and X-rays[5]. In addition' it has also been established that Sr_2CeO_4 exhibits photoluminescence under excitation with irradiation of ultraviolet rays[6,7]. Therefore, it has been attracted that Sr_2CeO_4 has good potential for application as a blue phosphor in lamps and in field emission displays.

The luminescence associated with Eu^{3+} contained in different host lattices has found applications related to its red light emission which is important in the fields of displays, sensors and lasers. The past few decades have seen a lot of work reported on the use of divalent/trivalent europium as a dopant in phosphors, as they have very good optical properties (in the blue to red regions) which make them part of many display devices. Among all the rare-earth ions, Eu^{3+} is the most extensively studied owing to the simplicity of its spectra and also its use in commercial red phosphors. The luminescence spectrum of Eu^{3+} reveals spectroscopic transitions from the visible to the near-infrared region. Sr_2CeO_4 and $Sr_2CeO_4:Eu^{3+}$ phosphor samples were prepared by the solid state reaction. Phase identification of all the powders were carried out by X-ray powder diffraction. Photoluminescence spectra of phosphors prepared have been presented in this paper.

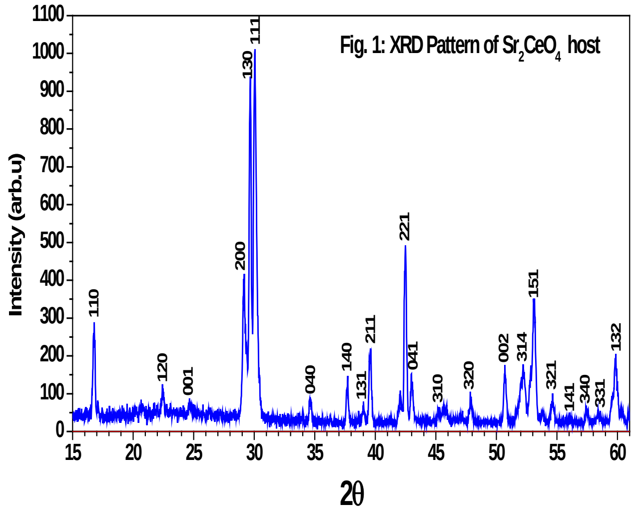
2. Experimental details

Sr_2CeO_4 and $Sr_2CeO_4:Eu^{3+}$ phosphor samples were prepared by the conventional solid state reaction method. Strontium carbonate $SrCO_3$ and Cerium Oxide CeO_2 (high purity chemicals) were used as stating materials for preparation of blue phosphor Sr_2CeO_4 and added them as a stoichiometric proportions of Sr:Ce as 2:1. The compound obtained was grounded into a fine powder and fired at 1200°C for 3 hours in a muffle furnace. The obtained powders were characterized by means of scanning electron microscopy (CP 30 Philips) and powder X-ray diffraction (XRD, Rigaku-D/max 2500 and Cu Kα radiation).The emission and excitation spectra were recorded at room temperature using Spectrofluorophotometer (SHIMADZU, RF-5301 PC) using Xenon lamp as excitation source.

3. Results and discussion

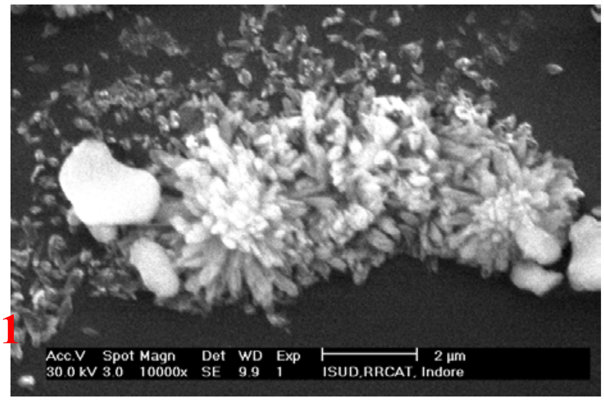
3.1 XRD Analysis

In order to determine the crystal structure, phase purity, chemical nature and homogeneity of the Sr_2CeO_4 phosphor, X-ray diffraction analysis was carried out. Figure-1 shows the XRD pattern of Sr_2CeO_4 host and the XRD pattern of $Sr_2CeO_4:Eu^{3+}$ (0.5%) shows the same pattern with less intensity. From the XRD pattern analysis it was found that the prominent phase formed is Sr_2CeO_4 and well matched with the JCPDS card No 050-0115. This reveals that the structure of Sr_2CeO_4 is Orthorhombic, which agrees with the findings of previous research works of Danielson et al[4], Sankar et al[9]and Shu-Jian Chen et al[10]. However, the data reported by Jiang et al[5] and Serra et al[8] indicate triclinic structure. From XRD data by using the Scherer's formula the calculated mean crystallite size of Sr2CeO4 and Eu (0.5%) doped Sr_2CeO_4 is 28, 31nm respectively. The Sr_2CeO_4 sample prepared by the solid state reaction in air at 1373k for 2hr showed phase separation. Calcination of the solid state sample at higher temperature induced homogenization and the Sr_2CeO_4 single phase was obtained after heating at 1573k for 24hr. As a result, it is elucidated that the single phase could be synthesized at higher temperatures.



3.2 SEM Analysis

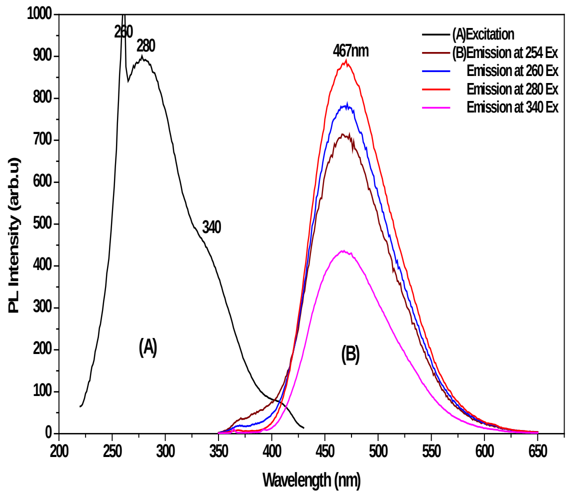
SEM images for Sr_2CeO_4 particles obtained by solid state reaction at 1200^0C the particles accelerated aggregation and sintering of the particles. Figure-2 shows the SEM micrograph of the pure Sr_2CeO_4 phosphor. The microstructure appears to consist of



ellipsoidal flakes type particulates having an average basal diameter of ~450nm and a length of ~1.4µm.

3.3 Photoluminescence Analysis

e excitation and emission spectra of Sr_2CeO_4 host and Sr_2CeO_4: Eu^{3+} (0.5%) are shown in figure-3a and b respectively. The excitation spectrum is same for both, shows peaks at 254, 260, 280 and 340nm. But the emission spectrum of Sr_2CeO_4 shows a broad band due to f→ t_1g transitions of Ce^{4+} (Figure-3a, curve B). When the excitation was varied from 254 to 340 nm the observed emission is a broad one and peaked only at 467nm for the entire range. It is also observed that the emission intensity is high when excited with 280nm. The excitation peak was mainly observed at 280 nm along with a small hump around 340nm as shown in figure 3a. This is mainly due to the charge transfer position of the Ce^{4+}-O^{2-} ligand as described by Danielson et al[10]. The two excitation peaks may be assigned to the two kinds of Ce^{4+} ions present Sr_2CeO_4. There are two different Ce^{4+}-O^{2-} bond lengths in the lattice and hence two different charge transfer transitions[10]. The hump around 280 or 340nm evident in the excitation curve may be attributed to the above mechanism.



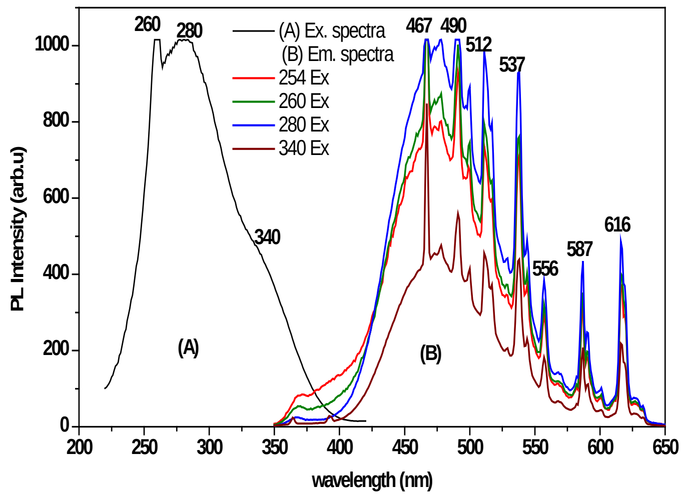
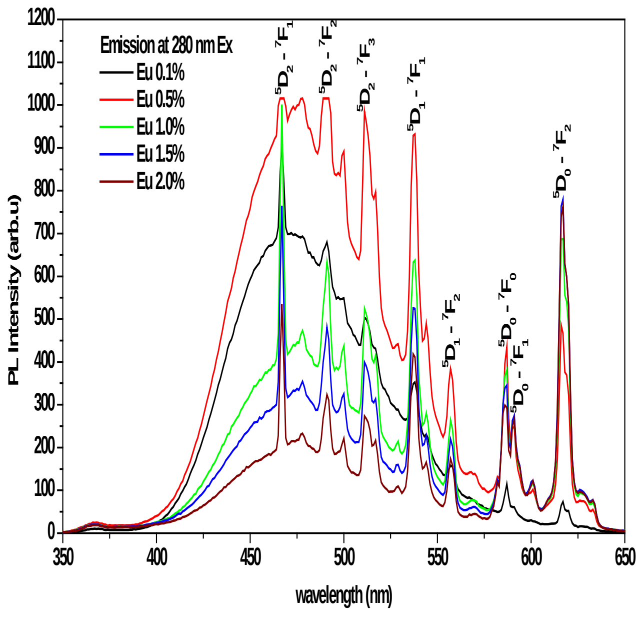


Fig.3a: The Excitation and Emission spectra of (0.5%)
Sr$_2$CeO$_4$ phosphor under different excitations under different excitations

Fig.3b: The Ex. and Em. Spectra of Sr_2CeO_4: Eu^{3+}

The Sr_2CeO_4 phosphor doped with Eu^{3+} (0.5%) does not show any change in the excitation spectrum. Figure-3b shows emission spectrum, peaks at 467, 490, 512, 537, 556, 587 and 616nm. The peaks depicted in the spectra are from the transitions $^5D_2 \rightarrow ^7F_{1,2,3}$, $^5D_1 \rightarrow ^7F_{1,2}$ and also from $^5D_0 \rightarrow ^7F_{0,1,2}$,. The peak around 610- 620nm is due to the electric dipole transition of $^5D_0 \rightarrow ^7F_2$ which is induced by the lack of inversion symmetry at the Eu^{3+} sites and is much stronger than the $^5D_0 \rightarrow ^7F_1$ transition. It is

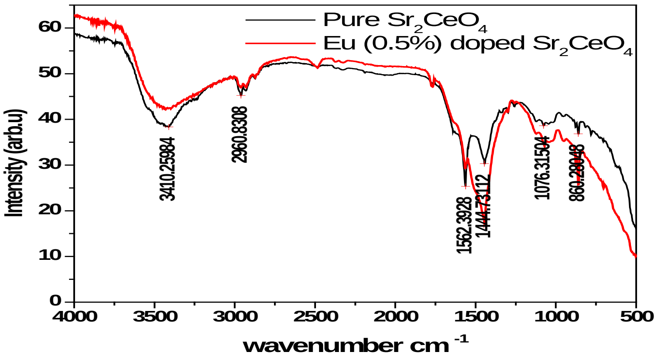


well known that the $^5D_0 \rightarrow ^7F_2$ / $^5D_0 \rightarrow ^7F_1$ intensity ratio is a good measure of the site symmetry of rare-earth ions in a doped material. This is because the hypersensitive transition $^5D_0 \rightarrow ^7F_2$ tends to be much more intense at a site with no inversion symmetry, while the magnetic dipole transition $^5D_0 \rightarrow ^7F_1$ is constant, regardless of the environment[11].

3.4 FT-IR Analysis

Fig.4 shows FTIR spectrum and it is observed that the peak at 3410 cm^{-1} is assigned to H_2O. The specimen might have absorbed Moisture from the atmosphere. The absorption peaks at 1562, 1444, 1076 and 860 cm^{-1} were assigned to stretching characteristics of $SrCO_3$.

Fig.4 : FTIR Spectrum of Pure Sr_2CeO_4 and Eu doped Sr_2CeO_4



4. Conclusions

PL studies of Sr_2CeO_4 and Sr_2CeO_4: Eu^{3+}phosphors prepared by solid state reaction method are presented in this paper. XRD pattern of Sr_2CeO_4 phosphor reveals that the structure of Sr_2CeO_4 is orthorhombic, which agrees with the findings of previous research works of Danielson et al[8]. The XRD pattern of Sr_2CeO_4 phosphor shows the formation of a single-phase compound. SEM images for Sr_2CeO_4 particles obtained by solid state reaction at 1200^0C the particles accelerated aggregation and sintering of the particles. The emission spectrum of Sr_2CeO_4 shows a broad band due to f→ t_1g transitions of Ce^{4+}.The two excitation peaks may be assigned to the two kinds of Ce^{4+} ions present Sr_2CeO_4. There are two different Ce^{4+}-O^{2-} bond lengths in the lattice and hence two different charge transfer transitions[12]. The Sr_2CeO_4 phosphor and Sr_2CeO_4 phosphor doped with Eu^{3+} (0.5%) shows highest PL Intensity when excited with 280nm. The Sr_2CeO_4:RE^{3+} emission could be tuned from blue to white and red light by varying the concentration of RE^{3+}. Hence Sr_2CeO_4 and Sr_2CeO_4:Eu^{3+} are good hosts for lighting applications as white light in LED's.

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