ISSN PRINT 2319-1775 Online 2320-7876, www.ijfans.org
Vol.11, Iss.7, Dec- 2022

Research Paper
UGC CARE Listed (Group -I) Journal

Synthesis and Characterization of Phosphors Doped with Various Rare Earths

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Abstract:

A blue emitting powder phosphor, Sr_2CeO_4 was prepared using a solid-state reaction technique. Powders grown at 11000C for 3 hours yielded good luminescence. The emission peak of this phosphor is 470 nm. In order to effectively use this phosphor in a tricolour lamp, studies have been carried out to see the effect of rare earth dopants on the luminescence spectra of this phosphor. The effect of dopants on the performance of the phosphor has been evaluated and the effect of using these dopants and the physical characterization of these phosphors using optical and structural techniques are discussed in this paper.

Introduction:

Plasma display panels (PDP) are replacing traditional color televisions. A top priority in the phosphor sector today is to replace expensive high performance rare earth active phosphors with cheaper equivalent materials. This means replacing the rare earth ions with transition metal ions or post-transition ions. Advances in optical spectroscopy of solids, especially transition metal ions in phosphors, and research on solid-state luminescence helped to develop. In the 1960s, efficient rare earth active phosphors were developed for use in color television (Tb^{3+}-green, Eu3+-red and Dy^{3+}-yellow) and in the 1970s a tricolor lamp was introduced. Blue emission from Eu^{2+}, red emission from Eu^{3+} and green emission from Ce^{3+} - Tb^{3+} pair were used in tricolor lamp. Currently, a combination of halo phosphate and tri-band phosphor mixtures is commonly used in many lamps as a compromise between performance, phosphor cost, and lamp manufacturing cost. However, better materials are needed to improve the performance of already existing low-cost phosphors. One such material is strontium cerate, a phosphor based on this material was synthesized and characterized using photoluminescence. XRD and Scanning Electron Microscope (SEM) techniques.

Experimental:

Pure rare earth doped Sr_2CeO_4 phosphor samples were prepared by conventional solid state reaction method. Strontium carbonate SrCO3 and cerium oxide CeO2 (high purity chemicals) were used as statting materials to prepare blue phosphor Sr2CeO4 and added as stoichiometric ratio Sr: Ce 2:1. The obtained compound was ground into a fine powder and fired in a muffle furnace at 11000C for 3 hours. Photoluminescence spectra were recorded at room temperature using a spectrofluorophotometer (Shimadzu, RF-5301 PC). XRD (Rigaku-D/max 2500 make with Cu Kα radiation) and SEM (XL30 CP Philips) studies are carried out on the prepared samples for microstructure evaluation.

Result and Discussion:

SEM micrograph of pure phosphor. The microstructure consists of elliptical flakes type particles with an average basal diameter of ~ 450 nm and a length of 1.4 µm. To determine the crystal structure, phase purity, chemical nature and homogeneity of the Sr_2CeO_4 phosphor, X-ray diffraction (XRD) studies were carried out for the as-prepared pure sample and rare-earth doped samples. Following figure XRD pattern of Sr_2CeO_4 sintered at 1100^0C and shows experimentally observed XRD peak positions for pure Sr_2CeO_3 and Sr_2CeO_4. The XRD pattern of Sr_2CeO_4 shows the formation of Sr_2CeO_4 as the predominant single-phase compound with traces of Sr_2CeO_4. XRD spectra of strontium cerate samples doped with different rare-earths. The following figure below shows the excitation spectra and emission spectra of this phosphor. When Sr_2CeO_4 emits with 285nm, the emission spectrum peaks at 470nm and covers the entire blue region with very good intensity. The excitation spectrum of Sr2CeO4 sample shows excitation peaks at 258, 265, 285 and 345nm for emission at 470nm. The emission spectrum of Sr_2CeO_4 shows a broad band due to the $f \rightarrow t_1g$ transition of Ce^{4+}.

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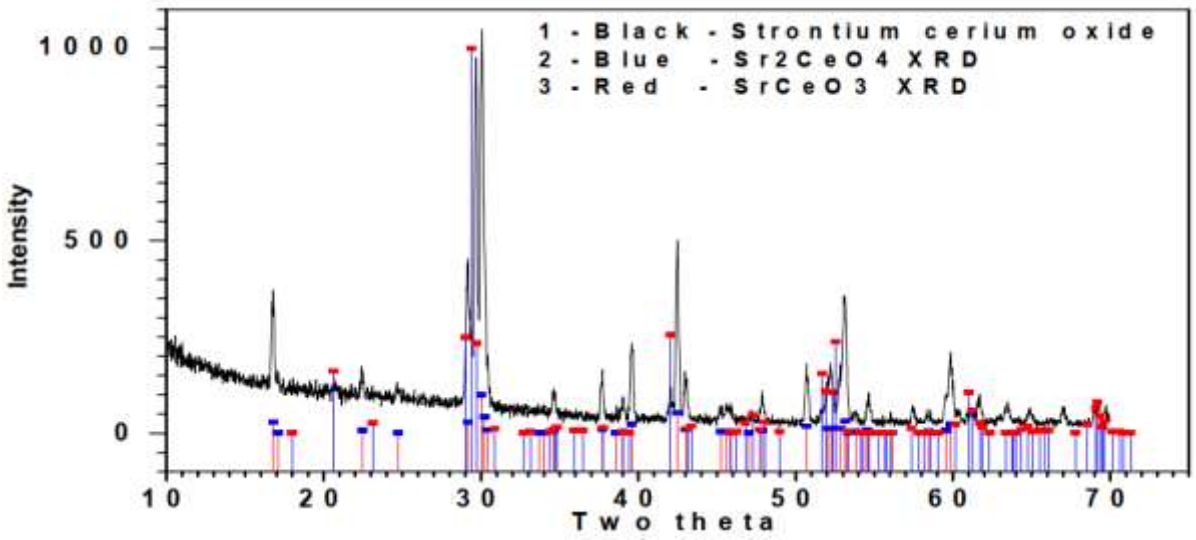
However, the effect of various dopants improved the emission energy range but decreased the intensity. Sr_2CeO_4 phosphor doped with different rare-earth dopants (0.5%) shows no change in excitation spectrum Emission spectra for rare-earth doped phosphors were recorded using 258nm excitation. This gives a change in the luminescence observed with different rare earth ion doping (0.8%). recorded at 256nm at room temperature but show peaks at 469, 492, 514, 539, 558, 589 and 616nm upon excitation with the corresponding emission spectrum for the Eu^{3+}(0.8%) doped phosphor. The peaks depicted in the spectra are from the transitions $^5D_2 \rightarrow {}^7F_{0,2,3,}$ $^5D_1 \rightarrow {}^7F_{0,1,2,3}$ and $^5D_0 \rightarrow {}^7F_{1,2,3}$. The peak around 610 -620nm is due to the electric dipole transition of $^5D_0 \rightarrow {}^7F_2$ 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 $^5D_0 \rightarrow {}^7F_1$ / $^5D_0 \rightarrow {}^7F_1$ intensity ratio is a good measure of the site symmetry of rare-earth ions in doped materials.

Figure 1.1 XRD of Sr_2CeO_4 phosphor



Conclusion:

XRD data analysis of Sr_2CeO_4 phosphor shows the formation of majority single phase compound with Sr_2CeO_3. SEM data revealed that the particle size average basal diameter was ~450 nm. The emission spectrum of Sr_2CeO_4 shows a broad band due to the f → t_1g transition of Ce^{4+}. Two excitation peaks can be assigned to the two types of Ce^{4+} ions present in Sr_2CeO_4. The lattice has two different Ce^{4+}- O^{2-} bond lengths and therefore two different charge transfer transitions. Sr_2CeO_4 phosphors doped with various rare-earths (0.5%) show that good PL intensity can be useful in various sources for lighting applications.

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