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Photoluminescence Studies of Sr_2CeO_4 Nano Phosphor

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Abstract: The present paper reports the photoluminescence studies of Sr_2CeO_4 phosphor prepared using sol-gel technique. The photoluminescence and crystalline properties were examined as function of the firing temperature. XRD pattern of sol-gel synthesized sample at different temperatures have been recorded. The scanning electron microscopy studies have been done on the prepared samples. The sol-gel synthesized sample shows the formation of nano sized particles. Photoluminescence results show that this phosphor can be suitable for field emission displays as well as fluorescent lamps.

Key words: Photoluminescence · Nano phosphors · Solgel technique · XRD · SEM

INTRODUCTION

The phosphor research has taken a great shape and the current trends in the research and development are to make use of newer and older methods to make the research viable today. 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 counterparts. Generally, the observed luminescence in nanocrystalline 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 [1]. For the last one and half decade the nanotechnology, with size limitation of less than 100nm, has been moving at a pace and gaining momentum, research in this field is becoming more and more active [2, 3]. 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, using sol-gel method, nano crystal phosphors with crystallite sizes less than 100nm.

MATERIALS AND METHODS

The Sr_2CeO_4 phosphor is prepared by Sol-Gel Technique. The materials in preparation of sample were $Sr(NO_3)_3$, $Ce(NO_3)_3$. $6H_2O$ and the fuel used were urea and citric acid. The stoichiometric ratio of Sr:Ce was kept at 2:1. All the materials of 99% used for the synthesis. Phase identification of the powders was carried out by the X-ray powder diffraction using RIGAKU D'MAX III Diffractometer having Cu Kα radiation (λ =1.54nm). The scan range was kept from 5 degrees to 80 degrees at the scan speed of 0.05 degree per second. The Scanning Electron Micrograph images (SEM) of the samples were taken using JEOL make JSM-5610 LV for studying the morphology of the compound. The photoluminescence {PL} (Emission and Excitation spectra) were recorded at room temperature using spectrofluorophotometer RF-5301 PC of SHIMADZU make. The source is a xenon lamp. The slit width for the emission and excitation was kept at 1.5nm for all the measurements. A filter was used to remove the second order peak of the excitation light in the PL measurements.

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RESULTS AND DISCUSSION

The Figure 1 shows the XRD pattern of the samples for solid state and sol-gel synthesized, the curves A, B and C stands for sample heated at 800, 1000 and 1200°C for sol-gel and solid state respectively. We have found out that the phase formation of the compound when synthesized by the sol-gel method at 1200°C is the most pure and matching with the literature [4]. The SEM micrographs have been taken for the Sr_2CeO_4 prepared by different synthesis technique at different temperatures. The SEM gives an insight to the morphology of the sample and also information regarding the shape and size of the particles. The SEM micrographs indicate that the morphology of the samples prepared by the sol-gel is better.

The Figure 2 shows the emission spectra of sample at 800, 1000 and 1200°C respectively. There is a clear indication of the peaks that appear at 1200°C whereas the peaks at 800°C and 1000°C are very weak in comparison to the 1200°C peak. This can be attributed to the fact that as the temperature was increased from 800 to 1200°C the formation of pure phase occurred, the observed luminescence from the phosphor at 800°C was due to the fact that some amount of luminescent phase Sr_2CeO_4 was present at such a low temperature too and that has contributed to the PL spectra, as the other phases are non luminescent one can say that the Sr_2CeO_4 phase had appeared at less than 800°C. The appearance of the broad band at 470nm is attributed to the $Ce^{4+} \rightarrow O^{2-}$ charge transfer transition. This is the kind of luminescence which is opposite to that of the phenomenon known as charge transfer absorption. Though there is slight variation in the position of the appearance of the band which varies from 467nm in some cases to 485nm in the other. The reason still remains the same i.e the charge transfer band.

The Sr_2CeO_4 sample prepared by sol-gel method was excited with different wavelengths from 240nm to 360nm for the sample at 1200°C, the interesting result that we can observe from the Figure 3 is that the peak position does not change much with the wavelength. Another interesting feature of these emission curves is that when the excitation wavelength was kept at 254nm the peak was very broad and it was of the highest intensity (out of range), also similar feature (out of range) was observed at 250nm, 280nm, 310nm with the next maxima at 280nm. The shape of the emission curve was same at all the wavelengths. This phosphor can thus be excited from broad range of excitation (240nm to 340nm). Such type of broad excitation can be useful for many applications [5-9]. Annealing for longer duration increases the intensity, which may be due to the removal of oxygen vacancy related defect centers as also reported by Pieterson *et al.* [10] and Nag *et al.* [11] and Pallavi *et al.* [12]. The broad band of the emission starts from around 370nm peaks at 475nm (2.61eV) and ends at 570nm. This fact also elucidates that the sample kept for further heating had good intensity due to more pure phase formation.

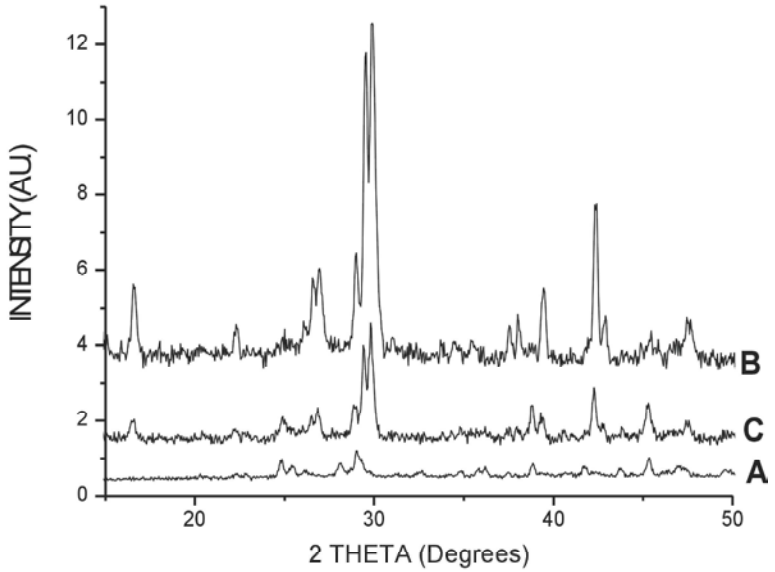

Fig. 1: XRD Patterns of the sol-gel-synthesized samples A, B and C

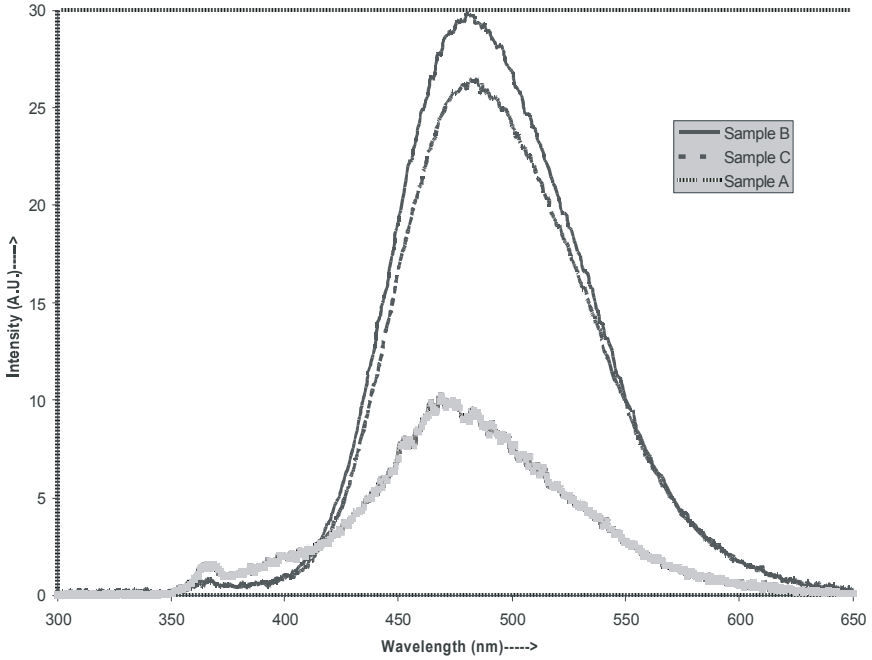

Fig. 2: The photoluminescence emission spectra of the Sr_2CeO_4 sol-gel synthesized sample excited at 254nm

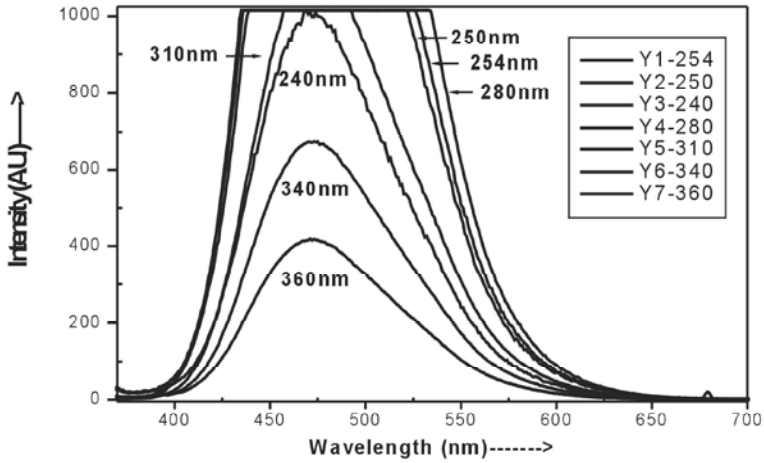

Fig. 3: The photoluminescence emission spectra of the sol-gel synthesized sample at different excitation wavelengths

CONCLUSIONS

Overall results shows that the powder samples of Sr_2CeO_4 prepared by the sol–gel technique exhibits high homogeneity, more uniformity and nano crystalline size (~45 nm). The luminescence intensity is also higher in the sample of sol-gel technique; further, the photoluminescence intensity at room temperature increases as the firing temperature was increased from 800 to 1200°C. There was remarkable 'blue shift' in the emission and excitation spectra for the sol-gel synthesized and the combustion. This may be attributed to the effect of size on the luminescence emission from the Sr_2CeO_4.

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