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Synthesis and Characterization of $SrAl_4O_7$:Eu Nanophosphors

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Abstract

Monoclinic Eu activated Strontium aluminate phosphor was successfully synthesized by a sol–gel method method at a relatively low temperature . The prepared samples were characterized by X-ray diffraction (XRD) analysis, scanning electron microscopy (SEM), and photoluminescence emission spectra (PL). The photoluminescence emission was obtained at 395 nm, 520 nm,790 nm corresponding to blue, green and IR region of the spectrum, respectively.The XRD analysis showed that $SrAl_4O_7$: Eu have monoclinic structure.

Keywords: XRD, FTIR, SEM, sol–gel method , Photoluminescence.

INTRODUCTION

The scientific researches on phosphors have a long history going back to more than 100 years.The rare earths are a unique series of elements in so far as they have an inner shell of electrons which is not full. The *3d* and *4d* shells of the first and second transition series elements are also unfilled but they are admixed to some extent with the valence band permitting the *d* electrons to become involved in chemical bonding. In the rare earth elements (lanthanides),however the unfilled 4f shell is truly an inner shell and the 4f electrons play little part in chemical bonding. Optical properties of rare-earth ions in nanostructure materials have also been extensively studied,the life time emission,the quantum- efficiency and the concentration quenching are some of the crystallite size-dependent properties in these materials [1–5]. The luminescent properties of these nano-materials make them attractive for many technological applications like display devices, up-conversion solar cells,white-light generation and detectors in medical diagnosis equipment among others[6,7]. Considerable efforts have been dedicated for the synthesis of rare-earth nano-phosphors with uniform size and shapes,by chemical means with techniques such as co-precipitation. Long persistent phosphors are those having very long afterglow emission or phosphorescence, in some cases even longer than a whole day, and a large application fields. Afterglow is caused by trapped electrons or holes produced during the excitation. The long persistent phosphorescence mechanism of the inorganic phosphors activated by rare earth ions have been attempted to be explained by many researchers. During the last decade, the researches on the development of new persistent phosphors and the improvement of their life time have been considerably conducted. During the last decades, the long-lasting phosphors have attracted much attention because they have extensive practical and potential applications in many fields, eg.emergent lighting, electronic displays, the detection of high-energy rays such as UV, X-ray, etc., and multi-dimensional optical memory and image storage.In this study, the photo luminescence properties of praseodymium ions incorporated in strontium aluminate ($SrAl_4O_7$:Eu) was investigated.

EXPERIMENTAL

The Sol-gel procedure of synthesizing nanoparticles is thoroughly described as follows:

98wt% of 2M Strontium acetate $[(CH_3.COO)_2Sr.2H_2O]$ was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring. Simultaneously, 1 wt% of 2M Europium nitrate $Eu(NO_3)_3 .6H_2O$ was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring. 1 wt% of 2 M Aluminum acetate ($C_4H_6AlO_4.4H_2O$) was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring and subsequently, it was added to the first solution to reach 50 ml in total. Then it was stirred for 30minute at room temperature for the second time. Ammonia was slowly added to this solution with constant stirring until a pH of 10.5 was achieved. After stirring of the solution for 30 min, acetic acid and ethylene glycol in the ratio 1:1 was added to the solution. The sol was heated at 80°C while being mechanically stirred with a magnetic stirrer. As the evaporation proceeded, the sol turned into a viscous gel. The gel was aged for 2h and then dried at 100°C for about 5h. The resulting materials were well grinded and annealed at 950°C for 5h to obtain $SrAl_4O_7$:Eu nanopowders.

RESULTS AND DISCUSSION

1. SEM.

SEM images $SrAl_4O_7$: Eu, which is un-uniform and may be due to the formation of fractal attribution to sort of self organization. SEM image of $SrAl_4O_7$ sintered at 900ºC for 3hrs appears to irregular shape and uniform morphology. The micrograph also showed that the surface morphology was in the form of granular structure with somewhat round shaped particles and interlinked with each other, leading to the formation of big crystals. Crystallite size has been calculated and obtained value for $SrAl_4O_7$: Eu was 75nm.

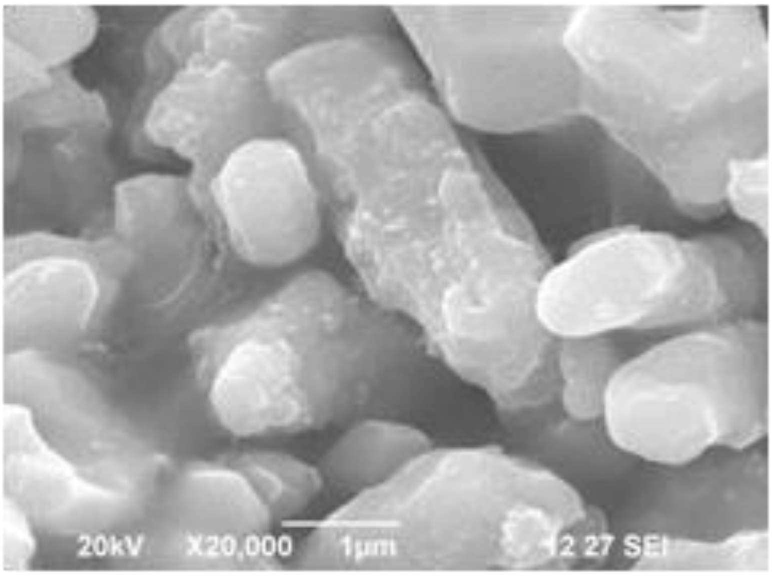

Figure 1: SEM images $SrAl_4O_7$: Eu

2. XRD Analysis

The structure and phase purity of the SrA1O: Eu phosphor were investigated by XRD. Fig.2 displays the X-ray diffraction patterns of $SrAl_4O_7$: Eu The patterns are consistent with SAO phases referenced in the Joint Committee of Powder Diffraction (JCPDS) file No.25-1289. Diffraction patterns were obtained using CuKα radiation (λ=1.54051 A^0). Measurements were made from $2\theta=10^0$ to 80^0 with steps of 0.02^0.The XRD patterns of the powders revealed that the structure of $SrAl_4O_7$: Eu is Monoclinic. The broadening of the diffraction peaks points to the presence of nanocrystalline domains. The result indicates that the obtained products are of high crystallinity and the small amount of Eu doped virtually has no effect on the phase structures.

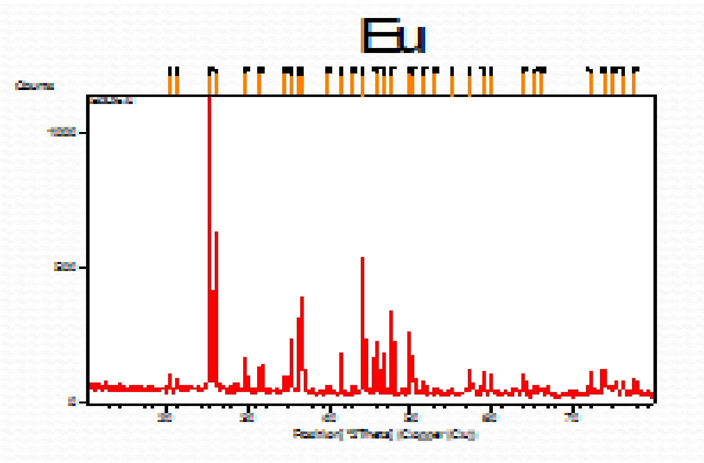

Figure 2: XRD images $SrAl_4O_7$: Eu

3. PHOTOLUMINESCENCE

The Photoluminescence emission spectrum of $SrAl_4O_7$: Eu phosphors are shown in Fig 3. Which is obtained under the excitation wavelength 360nm. When pure $SrAl_4O_7$ phosphors excited with 360nm emission gets peak at 395nm and 520nm, a perfect exciton emission and green emission with very good intensity. The spectra consist of three emission bands: a emission band at ~395 a week blue–green band at ~ 520 nm and a strong IR band at ~790 for SrAlO: Eu nanoparticles. It is well known that strontium aluminates phosphors show long phosphorescence in green region. The strong UV emission corresponds to the exciton recombination related near-band edge emission of nanoparticles. The weak blue and weak blue–green emissions are possibly due to surface defects in the nanoparticles. The week green band emission corresponds to the singly ionized oxygen vacancy in SrAlO. The low intensity of the green emission may be due to the low density of oxygen vacancies during the preparation of the nanoparticles, where as the strong room-temperature UV emission intensity should be attributed to the high purity with perfect crystallinity of the synthesized nanoparticles. It is well known that strontium aluminates phosphors show long phosphorescence in green region.

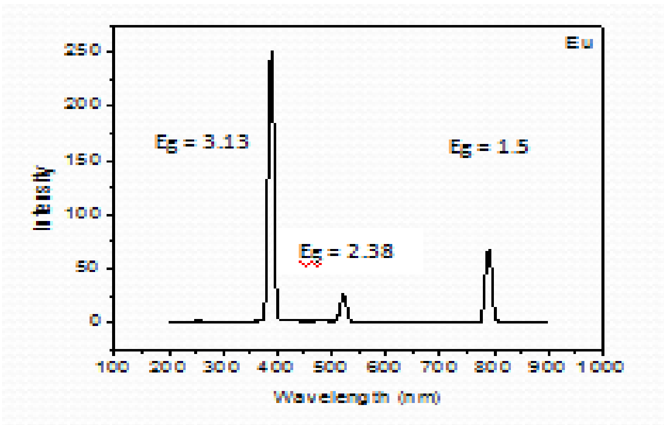

Figure 3: PL spectra of rAl_4O_7: Eu

CONCLUSION

Nanocrystalline $SrAl_4O_7$: Eu for l.% mol was prepared using sol-gel method at low temperature. The formation of the spinel phase was confirmed by X-ray diffraction data. Characteristic blue and green luminescence was observed in $SrAl_4O_7$: Eu nanophosphors at 395nm and 520nm. Crystallite size has been calculated and obtained value for $SrAl_4O_7$: Eu was 75nm. The XRD patterns of the powders revealed that the structure of $SrAl_4O_7$: Eu is Monoclinic. The result indicates that the obtained products are of high crystallinity and the small amount of Eu doped virtually has no effect on the phase structures. SEM image of $SrAl_4O_7$ sintered at 900ºC for 3hrs appears to irregular shape and uniform morphology.

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