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RESEARCH ARTICLE

SYNTHESIS BY SOL-GEL METHOD AND CHARACTERIZATION OF PR DOPED STRONTIUM ALUMINATE PHOSPHOR

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ABSTRACT

Pr doped strontium aluminate nanophosphor ($\text{SrAl}_4\text{O}_7:\text{Pr}$) was prepared by sol-gel method. The obtained materials were characterized by SEM, XRD, EDAX and PL. Monoclinic structure was confirmed by X-ray diffraction analysis, particle size was determined by Scherrer formula. The particles were of somewhat round shaped and interlinked with each other, leading to the formation of bigger particle. Also some irregular aggregations were found in the image. Photoluminescence emission were at 395, 520 and 790 nm corresponding to UV, green and IR regions under excitation for 360 nm.

Key words:

XRD,
FTIR,
SEM,
Sol-Gel Method.

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INTRODUCTION

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 (Psuja *et al.*, 2007; Kuo, 2010; Li and Lin, 2010; Niu *et al.*, 2011). 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 (Feldmann *et al.*, 2009; Hoppe, 2009). 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 ($\text{SrAl}_4\text{O}_7:\text{Pr}$) was investigated.

Experimental

The Sol-gel procedure of synthesizing nanoparticles is thoroughly described as follows: 98wt% of 2M Strontium acetate ($(\text{CH}_3\text{COO})_2\text{Sr}\cdot 2\text{H}_2\text{O}$) was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring. Simultaneously, 1 wt% of 2M praseodymium nitrate $\text{Pr}(\text{NO}_3)_3\cdot 6\text{H}_2\text{O}$ was dissolved in 25 ml of 2-methoxyethanol with vigorous stirring. 1 wt% of 2 M Aluminum acetate ($\text{C}_4\text{H}_6\text{AlO}_4\cdot 4\text{H}_2\text{O}$) 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 30 minute 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.

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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 SrAl₄O₇: Pr nanopowders.

RESULTS AND DISCUSSION

SEM

SEM images SrAl₄O₇: Pr, which is un-uniform and may be due to the formation of fractal attribution to sort of self organization. SEM image of SrAl₄O₇ sintered at 900°C 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.

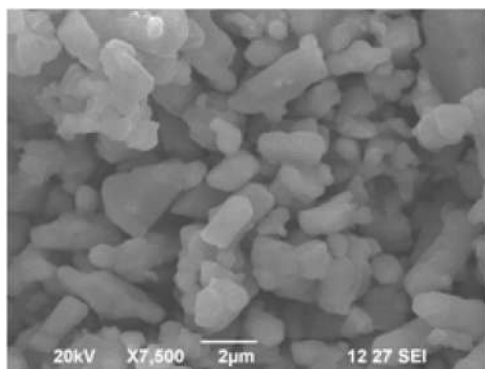


Figure 1. SEM images of Pr doped SrAl₄O₇

XRD analysis

The structure and phase purity of the SrAlO: Pr phosphor were investigated by XRD. Fig.2 displays the X-ray diffraction patterns of SrAl₄O₇:Pr. 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 CuK α radiation ($\lambda=1.54051 \text{ \AA}$), at 30kV and 15mA. Measurements were made from $2\theta=10^\circ$ to 80° with steps of 0.02° .

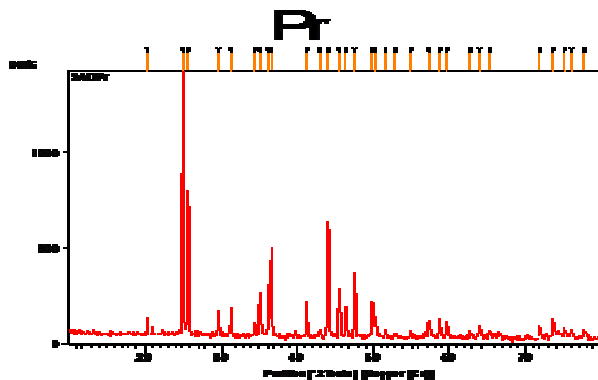


Figure 2. XRD images of Pr doped SrAl₄O₇

The XRD patterns of the powders revealed that the structure of SrAl₄O₇: Pr 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 Pr doped virtually has no effect on the phase structures. The average particle size attained for SrAl₄O₇: Pr was 74nm.

Photoluminescence

The Photoluminescence emission spectrum of SrAl₄O₇: Pr phosphors are shown in Fig 4. Which is obtained under the excitation wavelength 360nm. When pure SrAl₄O₇ 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 weak blue-green band at ~ 520 nm and a strong IR band at ~790 for SrAlO:Pr nanoparticles. It is well known that strontium aluminates phosphors show long phosphorescence in green region.

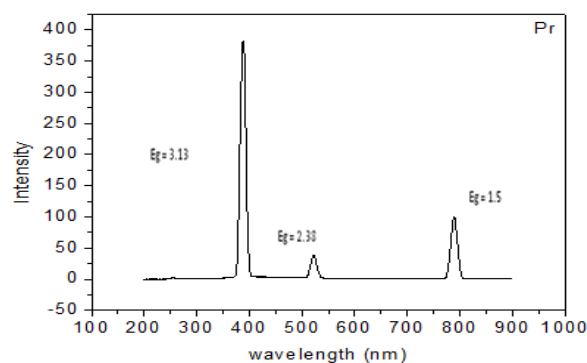


Figure 4. Photoluminescence spectrum for Pr doped SrAl₄O₇

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 weak 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.

Conclusion

Nanocrystalline SrAl₄O₇: Pr for 1% 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 SrAl₄O₇: Pr nanophosphors at 395nm and 520nm. Crystallite size has been calculated and obtained value for SrAl₄O₇: Pr was 74nm. The XRD patterns of the powders revealed that the structure of SrAl₄O₇: Pr is Monoclinic. The result indicates that the obtained products are of high crystallinity and the small amount of Pr doped virtually has no effect on the phase structures. SEM image of SrAl₄O₇ sintered at 900°C for 3hrs appears to irregular shape and uniform morphology.

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