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Effect of Calcinations Temperature on Photoluminescence Studies of 0.5zno-0.5sro-Al_2O_3

M R Revupriya[1], P S Anjana[2], N Gopakumar[1*], M S Anju[1]

[1]Post Graduate Department of Physics, Mahatma Gandhi College, University of Kerala, Trivandrum, Kerala, India.
[2]Department of Physics, All Saints' College, University of Kerala, Trivandrum, Kerala, India.
*gopkumar.n@gmail.com

Abstract

In recent times, alkaline earth aluminates earned considerable focus due to their comparatively intricate crystal frame work when compared with alternative inorganic luminescent hosts, which could produce more defect related traps when doped with RE and non RE ions. 0.5ZnO-0.5SrO-Al_2O_3 phosphor doped with Eu^{3+} ions was synthesized by the conventional solid state reaction methodology. X-ray diffractionpattern suggests that the sample possess mixed phases of $SrAl_2O_4$and $ZnAl_2O_4$. On UV excitation, the prepared phosphor reveals two rigid peaks which pertain to ($^5D_0 \rightarrow {}^7F_2$) and ($^5D_0 \rightarrow {}^7F_4$) transitions ofEu (III) ions identified at 619 nm and 702 nm in red region. PL intensity got boosted due to its direct relation with calcination temperature owing to the enhanced crystallinity. The orange-red emissions of phosphor 0.5ZnO-0.5SrO-Al2O3 possesslot of practical applications in the field of white LED fabrication.

Keywords: X-ray diffraction, absorption spectrum, photoluminescence

1. INTRODUCTION

Phosphors mainly find its applications in emissive display devices. Yet, all presently used phosphors still require substantial advancement viz., superior efficiency, lower current saturation, and improved chromaticity [1]. Studies reveal that RE doped AB_2O_4 exhibits strong photoluminescence in the visible region [2]. Spinels are a group of binary transition metal oxides having distinct structures and have possible applications in the field of material science. In the class of different spinels available, $ZnAl_2O_4$ (Zinc aluminate) - in spinel aluminate family, has earned a lot of focus due to its interdisciplinary interests [3]. In particular, Eu doped aluminate phosphors are being used due to their preferred features such as better efficiency, stability, ease of synthesis, less cost, non-toxic, non-hygroscopic nature and excellent luminescent properties when compared to normal sulphide phosphors [2]. Strontium aluminates, when activated with RE ions, are proved to be good luminescent materials displaying powerful luminescence in the blue-green region; admitting stable structures, prolonged afterglow lifetime, better quantum efficiency and can act as phosphors [4]. Among the known phosphors, Eu^{3+} excited phosphors to exhibit certain unique features such as high quantum efficiency, better colour rendering and photostability and hence they could be used as red phosphors in white LEDs [5].

In the on-going work, $0.5ZnO$-$0.5SrO$-Al_2O_3: Eu^{3+} sample was prepared by the popular solid-state reaction (SSR) method. Then the sample was subjected to calcination in an air atmosphere at 1200^0C for a period of 4 hours and finally characterized using XRD, UV and PL.

2. Synthesis and characterization

0.5ZnO-0.5SrO-Al2O3: Eu3+ prepared using high-temperature SSR method, starting reagents used were of high purity ZnO, SrCO3, Al2O3 and Eu2O3, which was brought from Sigma Aldrich. The stoichiometrically weighted raw materials using electronic balance were mixed assiduously for two hours using Agate mortar and pestle. The prepared slurry got dried up in a hot air oven. Subsequently, the sample got calcined at a temperature of 12000C for a period of 4 hours. Finally, the sample got finely grounded and structural examinations of the materials were carried out using XRD analysis [XRD D8 Advance Bruker]. The UV-Visible spectrum is taken in Perkin-Elmer Lambda 365 UV -Visible spectrometer. Photoluminescence was recorded using Horiba Fluorolog spectrophotometer.

3. Result & discussion

3.1. XRD analysis

Fig. 3.1 represents the XRD result of $0.5ZnO$-$0.5SrO$-Al_2O_3: Eu^{3+} shows mixed phases and are in tune with JCPDS Card No. (74-1138) *$ZnAl_2O_4$ and (74-0794) #$SrAl_2O_4$.

3.2. Optical absorption spectrum

Fig 3.2 shows the optical absorption spectrum of 0.5ZnO-0.5SrO-Al_2O_3: Eu^{3+}between 200-700 nm. The maximum absorption is at 393nm, near UV region.

3.3.Photoluminescence study

The emission spectra of 0.5ZnO-0.5SrO-Al_2O_3 doped using 0.1 M concentration of $Eu^{3+}$for 400-800 nm at three distinct temperatures viz., 1100^0C, 1150^0C, 1200^0C is represented in Fig.3.3. It is explicit from the spectrum that the emission peak of the samples calcined at 1200^0C turns into sharp and narrow corresponding to high intensity. Rise in calcination temperature results in a rise in PL intensity. The raise in calcination temperature results in a more organized structure by structural rearrangement and is reflected in emission spectra[6].

At 393nm excitation, the emission spectrum comprises a narrow band emission at 578, 587, 602, 608, 619, 657, 702 nm, which is attributed to the f-f level transition of Eu^{3+}. Eu ions can be in trivalent as well as divalent oxidation states. In the trivalent state, Eu(III) ions deliver a distinctive red light with numerous narrow peaks due to forbidden electric-dipole [$^5D_0$-^7F_j] transitions. The surrounding environments of the host matrix largely influence the luminous spectrum of Eu^{3+} ion. The less intense peak at 578 nm is an ED transition [$^5D_0$-$^7F_0$] which is visible in Cn, Cnv, and Cs symmetry. The peak observed at 587 nm is a MDtransition as a result of the $^5D_0$-$^7F_1$transition.The intensity of this MD transition is independent to the surrounding environment and the most intense emission at 619 nm is an ED transition [$^5D_0$-$^7F_2$] and hypersensitive one, whose intensity is highly dependent on surroundings. The less intense peak at 657 nm is a forbidden electric-dipole transition [$^5D_0$-$^7F_3$]. The peak at 702 nm is an electric-dipole one. It has been observed that most of the transitions are electric-dipole transitions. The ED transition is stronger than the MD transition, which reveals that the lower symmetry over Eu^{3+} ion [7].

4. CONCLUSION

Eu^{3+} activated 0.5ZnO-0.5SrO-Al_2O_3 phosphor was synthesized using solid state reaction process. XRD result suggests existence of mixed phases of $ZnAl_2O_4$ and $SrAl_2O_4$ in the sample. On UV excitation, the phosphor shows two intense peaks as a result of $^5D_0 \rightarrow {}^7F_2$

and $^5D_0 \rightarrow ^7F_4$ transitions of Eu^{3+} ions are observed at 619 nm and 702 nm respectively in red region. As calcination temperature increases PL intensity also increases due to enhanced crystallinity. By the systematic observations it is concluded that 0.5ZnO-0.5SrO-Al_2O_3: 0.1Eu can be an assuring material for white LED fabrication.

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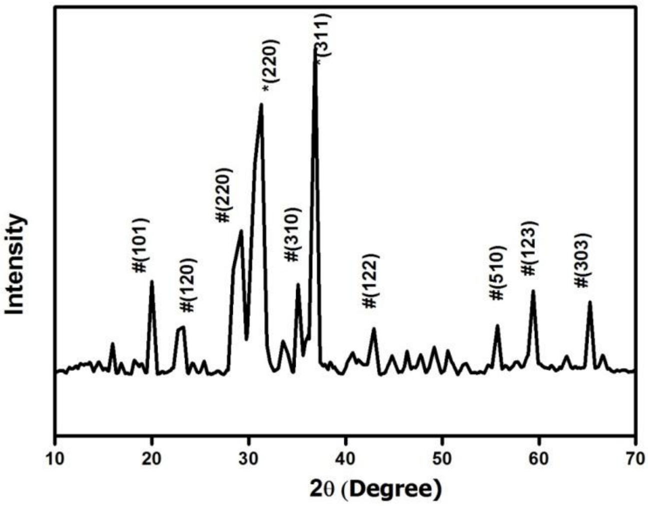

Fig.3.1. XRD pattern of 0.5ZnO-0.5SrO-Al_2O_3:Eu^{3+}

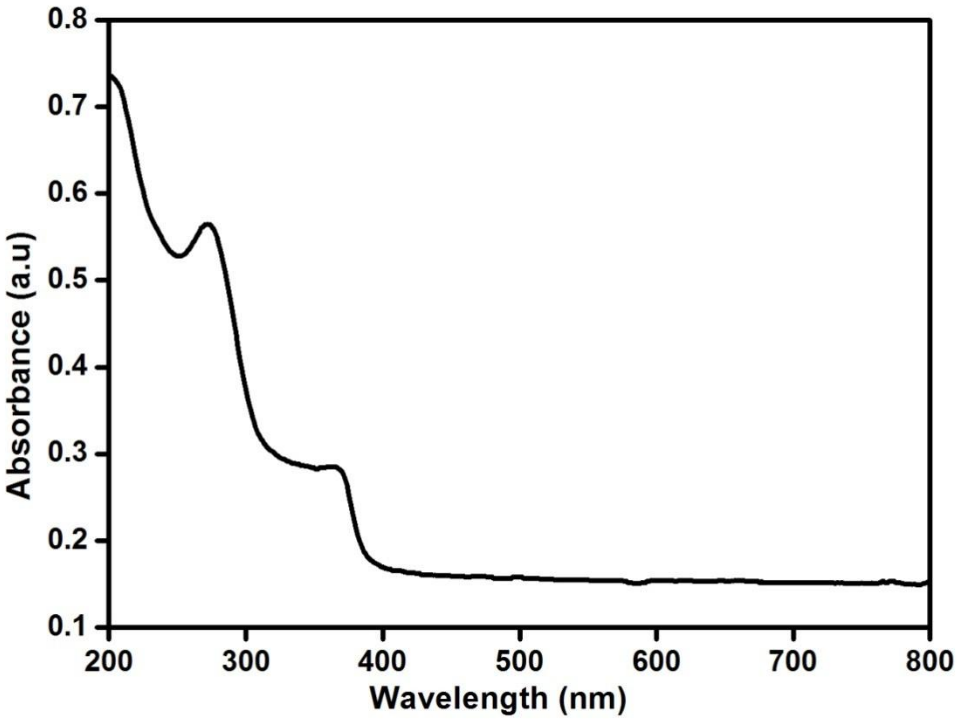

Fig.4.2. Optical absorption spectrum of0.5ZnO-0.5SrO-Al_2O_3:Eu^{3+}

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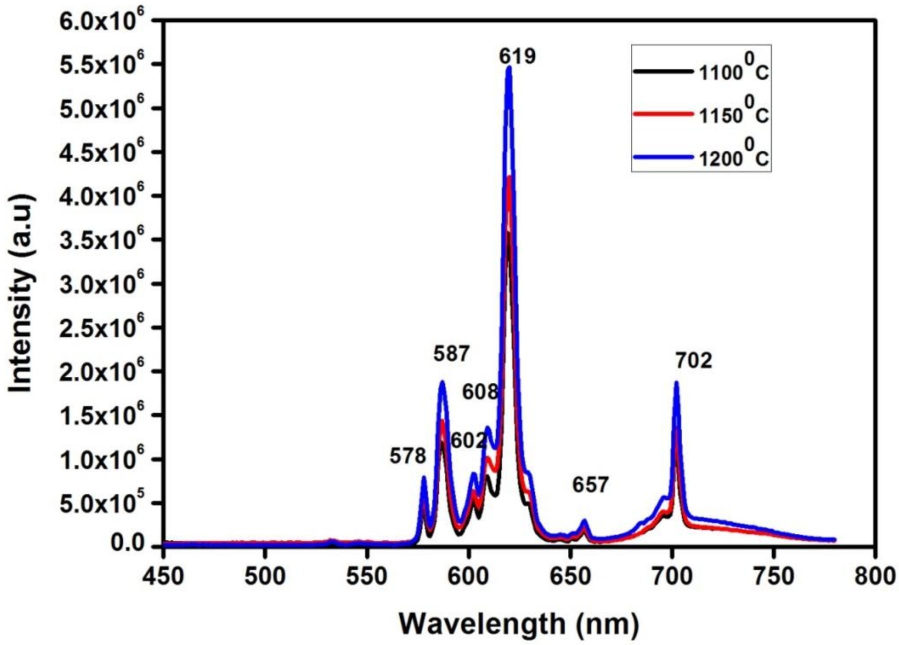

Fig.3.3. PL emission spectrum of 0.5ZnO-0.5SrO-Al_2O_3:Eu^{3+}