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Astrophysical Applications of Aluminum, Strontium Lanthanate Phosphors Doped with Terbium and Europium

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Abstract: *$Al_2Sr_2La_2O_8$ doped (ASL) with terbium and europium ion was synthesized by solid state reaction under air atmosphere. Its characterization was systematically analyzed by SEM, X-ray diffraction (XRD) and photoluminescence spectra (PL). Photoluminescence emission spectra having excitations at around 254, 268, 278nm revealed that Eu ions were present in trivalent oxidation states. The emission peaks are found at 540(green), 588,(Yellow) and 626nm(red) are observed. Scanning Electron Microscopy (SEM) was implemented to investigate the surface morphology of present phosphor. The obtained results on $Al_2Sr_2La_2O_8$: Tb, Eu is suitable for green-red light source using UV light as the primary excitation. In addition with Aluminum, Strontium Lanthanate phosphors are used for lighting can work to minimize electricity usage, and decreases the excess light pollution, minimizing light pollution has benefits for people and for the surrounding ecosystems. The best example of ASL is lighting use is around Peurto Mosquito, a bioluminescent bay on vieques, peurto rico ,the bioluminescence is more visible and healthier, and people's eyes get a few more minutes to adjust to the dark. Another use of the ASL is lighting is around the lowell astrophysical observatory. Astrophysical observatories require low lighting to properly see stars and often use best practices in light-pollution safe lighting. Now the observatory is lined with paths that glow at night. Researchers and visitors to safely find their way in the dark, without the use of bright electric lights.*

Keywords: Astrophysical Applications

I. INTRODUCTION

Ever demand for new and tough operating display device phosphors zeroed the aluminate compounds haven been utilized as host materials of lamp phosphors for many years, thanks to their relatively low material cost, and reasonable stability in lamp application. The development of the first synthesized. Strontium aluminates based afterglow pigments are marketed under numerous brand names such as Core Glow, Super-LumiNova and Lumibrite, developed by Seiko. Strontium aluminate cement can be used as refractory structural material. It can be prepared by sintering of a blend of strontium oxide or strontium carbonate with alumina in a roughly equimolar ratio at about 1500 °C. It can be used as a cement for refractory concrete for temperatures up to 2000 °C as well as for radiation shielding. The use of strontium aluminate cements is limited by the availability of the raw materials. Many companies additionally sell products that contain a mix of strontium aluminate particles and a 'host material'. Due to the nearly endless ability to recharge, strontium aluminate products cross many industries. Some of the most popular uses are for street lighting, such as the viral bike path. Strontium aluminates have been examined as proposed materials for immobilization of fission products of radioactive waste, namely strontium-90. Europium-doped strontium aluminate nanoparticles are proposed as indicators of stress and cracks in materials, as they emit light when subjected to mechanical stress (mechanoluminescence). They are also useful for fabricating mechano-optical nano devices. Non-agglomerated particles are needed for this purpose; they are difficult to prepare conventionally but can be made by ultrasonic spray pyrolysis of a mixture of strontium acetylacetonate, aluminium acetylacetonate and europium acetylacetonate in reducing atmosphere (argon with 5% of hydrogen).

II. Experimental

To prepare Aluminum, Strontium Lanthanate (ASL) doped with various concentrations of Europium, consists of heating stoichiometric amounts of reactants at 1500 °C for 2 h in a muffle furnace. The Eu^{3+} activated ASL phosphor was prepared via high temperature modified solid state diffusion. The starting materials were as follows: Aluminum Oxide, strontium carbonate , Lanthanum Oxide and the molar ratio of rare earth terbium oxide and Eu_2O_3 (National Chemicals, Baroda, 99.999%) was used to prepare the phosphor .The mixture of reagents was ground together to obtain a homogeneous powder in acetone base. After being ground thoroughly in stoichiometric ratios by using an agatealuminates phosphor can be traced back to 1970. In the 1980's rare-earth-activated aluminate phosphors were practically used in (BAM:Eu) fluorescent lamps. This was the first application of rare-earth-activated aluminates in tri band fluorescent lamps and represented a landmark in this history of fluorescent lamp development. Mortar, to ensure the best homogeneity and reactivity, powder was transferred to alumina crucible, and then heated in a muffle furnace at 1200 °C for 2 hr. The phosphor materials were cooled to room temperature naturally. All samples were found out to be white which are studied for photoluminescence. PL spectra were recorded at room temperature using SHIMADZU spectrofluorophotometer.

III. Results and Discussion

Figure I is the PL of ASL:Tb, Eu excited with 254, 268,278nm. The main PL peaks are observed at 540,588, and627nm with different intensities. However the red emission intensity at 627nm dominates all other emissions followed by 540,488 and 615nm.

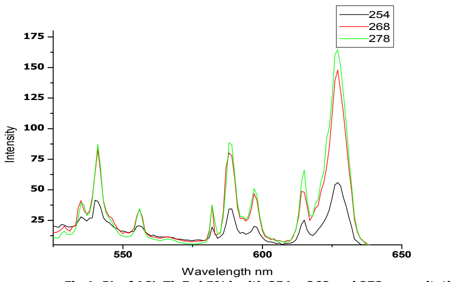

Fig.1: PL of ASL:Tb,Eu(.5%) with 254m 268 and 278nm excitation

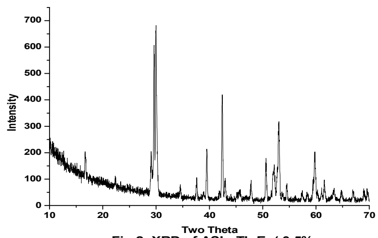

Fig.2: XRD of ASL: Tb,Eu(0.5%

All the observed peaks are allowed transitions of Europium when excited with254nm. The effect of Tb in ASL:Eu is not seen. The observed some main peaks and other small peaks are basically the allowed transitions of europium in +3 state. They are due to:

1. 515nm emitted peak is due to $^5D_2 \rightarrow {}^7F_3$ transition of Europium and is due to electric dipole with energy 2.429 eV.
2. 540nm emitted peak is due to $^5D_1 \rightarrow {}^7F_1$ transition of Europium and is due to electric dipole with energy 2.307 eV.
3. 626nm emitted peak is due to $^5D_0 \rightarrow {}^7F_3$ transition of Europium and is due to electric dipole with energy 1.985 eV and is due to electric dipole.

Fig. 2 is XRD of ASL:Tb,Eu(0.5%). The calculated crystallite size using Scherer's formula d=K.λ/ βCosθ, where 'K' is the Scherer's constant (0.94), 'λ' the wavelength of the X-ray (1.5418 Å), 'β' the full-width at half maxima (FWHM) (0.29^0), 'θ' the Bragg angle of the peak highest intensity is 29.5^0,Cosθ = 0.962 and for 0.5% Tb doped ASLis around 33.23 nm.

The morphological investigation of Eu doped ASL was carried out by scanning electron microscopy (SEM). The typical SEM image is shown in Fig. 3. SEM image reveals that the particles size and shape is irregular and size varies from 1-4µm with highly agglomerated particles are present in the phosphor. Use of Strontium Aluminates for lighting

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can work to minimize electricity usage, and minimizes excess light pollution. Minimizing light pollution has benefits for people and for the surrounding ecosystems. One example of strontium aluminate lighting use is around Peurto Mosquito, a bioluminescent bay on Vieques, Peurto Rico. The conservation trust there took out electric lighting around the bay, which was negatively impacting the circadian rhythm of the organisms which glowed by taking out the electric lighting, and installing a path that was lit up with the strontium aluminate system instead, tourists can still find their way from the parking lot to the bay, the bioluminescence is more visible and healthier, and people's eyes get a few more minutes to adjust to the dark.

Another use of strontium aluminate lighting is around the Lowell astrophysical observatory. Astrophysical observatories require low lighting to properly see stars and often use best practices in light-pollution safe lighting. Now the observatory is lined with paths that glow at night, enabling researchers and visitors to safely find their way in the dark, without the use of bright electric lights.

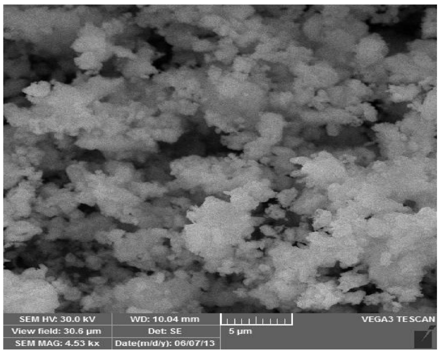

Figure 3: SEM of ASL:Eu (0.5%), Tb (0.5%)

Figure 4: SHIMADZU spectrofluorophotometer

IV. Conclusions

The emission peaks observed in $Al_2Sr_2La_2O_8$:Tb when excited with 254, 268, 278 nm at 540(green), 588(Yellow), and 627nm(red) are observed. As excitation wavelength the observed peak intensities are increased. However it is interesting to note the lesser the excitation energy the more PL output for 627nm peak whose intensity is more than 300% when compared the 254 vs 278nm excitations. The effect of Tb in ASL:Eu is not seen. The obtained results on $Al_2Sr_2La_2O_8$: Tb, Euphosphor is suitable for green-red lightsource using UV light as the primary excitation. Based on the above properties, the material has high hardness, causing abrasion to the machinery used in processing it; manufacturers frequently coat the particles with a suitable lubricant when adding them to a plastic. Coating also prevents the phosphor from water degradation over time. The glow intensity depends on the particle size; generally, the bigger the particles, the better the glow. Another use of strontium aluminate lighting is around the Lowell astrophysical observatory. Astrophysical observatories require low lighting to properly see stars and often use best practices in light-pollution safe lighting. Now the observatory is lined with paths that glow at night, enabling researchers and visitors to safely find their way in the dark, without the use of bright electric lights.

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