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Photoluminescence Properties of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ Phosphor

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ABSTRACT

$Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphors were prepared by combustion method. Prepared phosphor was characterized by photoluminescence properties. $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphors can be efficiently excited by solid state lighting excitation and shows intense yellow emission at 566 nm. Highest concentration of Eu^{3+} was observed at 1 mole % and no concentration quenching effect was observed. From the photoluminescence properties, we concluded that prepared phosphors may be applicable in development of ecofriendly based solid state lighting technology.

Keywords: Phosphor; aluminate; $Sr_2MgAl_{22}O_3$; combustion method; solid state lighting

I. INTRODUCTION

In the recent years, eco-friendly solid state lighting have attracted a lot of attention due to high efficiency, environmental friendliness [1]. First blue LED pumped white light emitting diodes were developed in 1986 [2]. Among the available various light emitting diodes, $YAG:Ce^{3+}$ phosphor have been widely used in white light emitting diodes [3]. White LED has been rapidly developed as a modern lighting source because of their potential merits like small size, long service lifetime and environmental friendliness [4,5]. However, such white LEDs have several disadvantages related to color rendering index, color quality and quenching at high temperatures and lack of red emission [6,7]. To overcome these disadvantages, it is better to develop a new type of LEDs with high CRI which have UV or NUV excitation. Recently rare earth doped aluminate based phosphor is one of the most used phosphor materials for development of ecofriendly solid state lighting due to their stable crystal structure, chemically stable, easy preparation and thermal stability [8,9]. Till date, aluminates were prepared by combustion method, solid state method and sol gel method. Out of these methods, combustion method is more suitable for synthesis of aluminates due to many advantages like easy synthesis, low energy consumption, low cost, requirement of low temperature and low reaction time [10,11]. The study on luminescence properties of Dy^{3+}, Eu^{3+}, Tb^{3+} and Sm^{3+} doped phosphors have shown enormous application in the solid state lighting due to their unique optical properties and electronic properties obtained from 4f shell of the ions. Europium ion has been frequently used in many hosts due to their ability to produce blue, red and green emissions from the various electronic configurations. Out of the available different rare earths, europium ion is one of the important rare earths for obtaining red emission under UV or NUV excitation when doped with different hosts like aluminates, silicates and phosphates [12-14]. For Eu^{3+} ions the emission located at around 615 nm (red emission) is due to the forced electric dipole transitions of $^5D_0 \rightarrow {}^7F_2$ [15]. Eu^{3+} ions shows characteristics emission lines in a host, in the wavelength range of 550nm - 750 nm due to the $^5D_0 \rightarrow {}^7F_j$ (J =0-4) transitions of Eu^{3+} ions [16,17]. In this work, we present luminescence properties of Eu^{3+} doped $Sr_2MgAl_{22}O_{36}$ phosphors prepared by combustion method.

II. EXPERIMENTAL

A series of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphor was synthesized by combustion method. AR grade $Sr(NO_3)_2$, $Mg(NO_3)_2$, $Al(NO_3 3$ and Eu_2O_3 were used as starting materials. Urea was used as fuel. All the precursors were weighed as per the stoichiometric ratio and transferred to a porcelain china dish. The precursor chemicals along with urea were mixed thoroughly until they formed a paste. The china dish containing this pate is then kept in a muffle furnace pre-heated to 550 ^oC. The combustion reaction takes place accompanied by a flame that lasts for 13 seconds. The resultant product has a porous nature with less crystallinity. The phosphor powder was then crushed and annealed at 800 ^oC for 4 hours. After cooling, the phosphors were collected and characterized for their photoluminescence (PL) properties. The photoluminescence (PL) excitation and emission spectra were recorded in Shimadzu RF5309PC Spectrofluorophotometer.

III. RESULTS AND DISCUSSION

Photoluminescence properties of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphor

Figure 1 gives the PL excitation spectra of the $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphors by monitoring the emission wavelength of 566nm. The highest excitation peak intensity was observed at 347 nm, so we choose this for obtaining the emission spectra. Figure2 presents the PL emission spectra of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ by exciting the phosphors at wavelength 347nm. The emission spectra of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphor shows characteristics emission due to Eu^{3+} ions. Emission spectra consist of three peaks located at around 566 nm, 591 nm and 615 nm. An intense yellow emission peak located 566 nm as compared with another emission peaks. Highest emission intensity was observed at 566 nm. The emission bands observed at 591 nm, 615 nm can be attributed due to $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$ transitions of Eu^{3+} ions respectively [18]. The emission at 591 nm can be attributed to magnetic dipole transition and emission at 615 nm can be attributed to electric dipole transition [19,20]. No broad band emission was observed which indicated that europium ion is in Eu^{3+} state in the $Sr_2MgAl_{22}O_{36}$ host. To find out the best dopant in prepared phosphor, we have prepared a series of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphors with different concentrations of Eu^{3+} ions. It can be clearly indicate that when we increase the concentration of Eu^{3+} ions the emission intensity increases upto 1 mole%. No concentration quenching effect was observed upto 1 mol% of Eu-concentration. The obtained photoluminescence results show that the $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphors may find potential applications in solid state lighting.

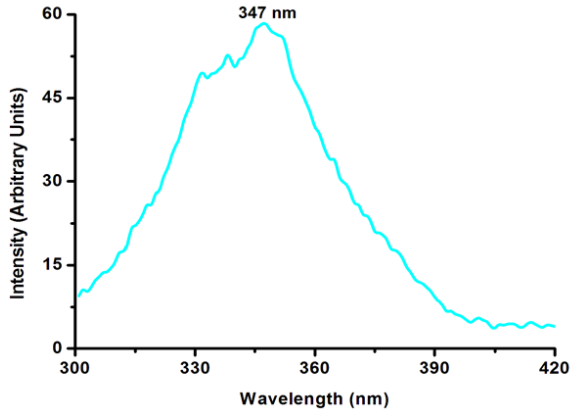

Figure 1. Excitation spectra of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphor where λ_{em}= 566 nm

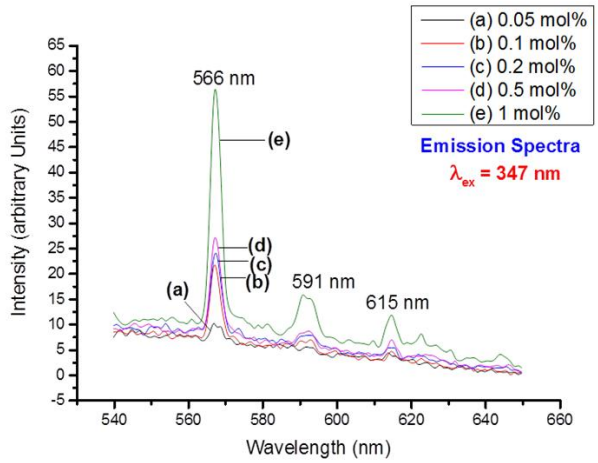

Figure 2. Emission spectrum of $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphor (λ_{ex}= 347 nm), where (a) Eu=0.05 mole% (b) Eu= 0.1 mole% (c) Eu= 0.2 mole (d) Eu= 0.5mole% (e) Eu= 1 mole%

IV. CONCLUSIONS

The $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphor was successfully synthesized by combustion method. Photoluminescence emission spectra exhibited characteristics emissions at 566 nm, 591 nm and 615 nm for 347 nm excitation. $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphors showed intense yellow emission at 566 nm. Photoluminescence result indicates that the $Sr_2MgAl_{22}O_{36}:Eu^{3+}$ phosphor can be potentially

used as an efficient material for ecofriendly solid state lighting technology.

V. REFERENCES

[1]. G. Ramakrishna, H. Nagabhushana, B. Daruka Prasad, Y.S. Vidya , S.C. Sharma ,

[2]. K.S. Anantharaju, S.C. Prashantha, N. Choudhary, J.Luminescence 181 (2017) 153.

[3]. J.J. Zhanga, R. Hua, X.J. Yua, B. Xie, X.B. Luo, Optics & Laser Technology 88 (2017) 161.

[4]. H. Amano, N. Sawaki, I. Akasaki, Y. Toyoda, Appl. Phys. Lett. 48 (5)(1986) 353.

[5]. P. Pust, P.J. Schmidt, W. Schnick, Nat. Mater. 14 (2015) 454.

[6]. R.J. Xie, H. Naoto, M. Mamoru, S. Ken, K. Naoki, , Appl.Phys. Lett. 89 (2006) 1-3, 241103.

[7]. J.J. Zhang, R. Hu, X.J. Yu, B. Xie, X.B. Luo, Optics & Laser Technology 88 (2017) 161.

[8]. S. Nakamura, G. Fasol, The Blue Laser Diode, Springer-Verlag, Berlin, 1997 87.

[9]. H.N.Luitel , T. Watari , R. Chand, T. Torikai, M. Yada, Optical Materials 34 (2012) 1375.

[10]. A.N. Yerpude, S.J. Dhoble , J.Luminescence 132 (2012) 1781.

[11]. Yiyao Ge , Siyuan Sun, Mengmeng Zhou, Ying Chen, Zhaobo Tian, Jie Zhang, Zhipeng Xie, Powder Technology 305 (2017) 141.

[12]. P. Mossino, Ceram. Int. 30 (3) (2004) 311.

[13]. S.J. Dhoble, Bhushan P. Kore, A.N. Yerpude, R.L. Kohale, P.W. Yawalkar, N.S. Dhoble, Optik 126 (2015) 1527.

[14]. A.N. Yerpude, V. R. Panse, S. J. Dhoble, N. S. Kokode, M.Srinivas, Luminescence. 2017;1.

[15]. V.R. Panse, N.S. Kokode, Alok Shukla, A.N. Yerpude, S.J. Dhoble, Optik 127 (2016) 5860.

[16]. X. Wang, J. Wang, J. Shi, Q. Su, M. Gong, Materials Research Bulletin 42 (2007) 1669.

[17]. S. Sharma, S. Pitale, M.M. Malik, R.N. Dubey, M.S. Qureshi, S.K. Vasisth, P. Pathak, Indian J. Eng. Mater. Sci. 16 (2009) 165.

[18]. S.K. Sharma, S.S. Pitale, M.M. Malik, R.N. Dubey, M.S. Qureshi,, Radiat. Eff. Defects Solids 163 (2008) 767.

[19]. F. M. Emen, R. Altinkaya , V.Kafadar, G.Avsar, T. Yes, N.Kulcu, J. Alloys and Compounds ,681 (2016) 260.

[20]. X. C. Jiang, C. H. Yan, L. D. Sun, Z. G. Wei and C. S. Liao, J. Solid State Chem., 175(2003) 245.

[21]. N. Baig, N.S. Dhoble, A.N. Yerpude, Vijay Singh, S.J. Dhoble, Optik 127 (2016) 6574.