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Synthesis and PL Characterization of $Zn_4B_6O_{13}$: Eu^{3+} Phosphor

Vandana R. Kharabe
Department of Physics, Kamla Nehru Mahavidyalaya, Nagpur, India
vandana_kharabe@yahoo.com

Abstract: *Modified solid state synthesis had been used to synthesize $Zn_4B_6O_{13}$:Eu^{3+} phosphor. Compared to other methods, modified solid-state synthesis has several advantages.. $Zn_4B_6O_{13}$:Eu^{3+} phosphor's' photoluminescence properties have been investigated.. The PL excitation spectra shows sharp peak at 393nm due to transition of 4f→5d. The shoulder peak of the PL emission spectra is observed at 614nm due to the $5D_o$→ $7F_2$ (red) transition of Eu^{3+} ion while the other peak is observed at 593nm due to the $5D_o$→ $7F_1$ (orange). All of the properties of the developed $Zn_4B_6O_{13}$:Eu^{3+}phosphor indicate that it could be beneficial in the lamp industry and solid state lighting.*

Keywords: Phosphor, PL

I. Introduction

Borate's improved UV transparency, good nonlinearity, and relatively high resistance against laser induced damage are all due to its special crystal structure. Borates make excellent hosts for the development of luminescent materials. As phosphor materials, a range of borate host materials doped with rare earth and other ions have been described for a variety of applications. [1].Due to their great stability, low synthetic temperatures, and high UV and optical damage thresholds, phosphors based on borates have recently gained a lot of attention. [2–4]. Borate crystals are naturally luminous and exhibit thermoluminescence as well as other optical features. [5, 6]. Borates have typically been utilised as optical materials for second harmonic generation or fluorescence. $LaBO_3$ and YBO_3 are rare earth orthoborates that have been shown to be excellent host lattices for the luminescence of Eu^{3+} and Tb^{3+}. They've been used in a variety of optical systems, including field emission displays, plasma display panels, and new Hg-free fluorescent lamps. [7, 8]. YBO_3:Eu^{3+} and YBO_3:Tb^{3+}, for example, are currently used as red and green components in PDP television. [9, 10]. These rare metal ions and their compounds are, however, highly expensive, and their excitation maxima have remained in the vacuum UV region, restricting their use to specific areas. [11, 12]. Due to weak absorption (parity prohibited transitions) within the 4f shell, the emission efficiency of Eu^{3+} ions in most hosts is quite low when excitation occurs in the soft UV or blue energy range. [13]. However, the Eu^{3+} ions show good efficiency under UV radiation due to related host absorption (charge transfer band) or indirect excitation via the energy transfer mechanism via host absorption.This technique has a low efficiency for most RE-doped materials, notably glasses, because the energy is virtually totally lost in the glass host. [14]. By manipulating/selecting suitable host materials with low band gap or constructing the crystal lattice with low symmetry so that the forced electric dipole f-f transition of the Eu3+ ions is pronounced, the photoluminescence efficiency in the soft UV to blue excitation range can be increased through associated host absorption and energy transfer or forced direct transitions. As a result, discovering less expensive phosphor materials with superior optical-thermal stability and a better efficiency when activated by near UV to visible light is important. Flame retardants, smoke suppressants, afterglow suppressants, corrosion inhibitors, and synergistic agents have all been researched extensively using zinc-borate and its hydrates. [15–17].The photoluminescence properties of $Zn_4B_6O_{13}$: Eu^{3+}phosphors were examined in this work after they were synthesised using a solid state reaction technique.

II. Experimental

A modified solid-state diffusion technique was used to synthesize the phosphor $Zn_4B_6O_{13}$:Eu^{3+}. The starting materials were a stochiometric mixture of reagent $ZnCO_3$, $H_3BO_3$and Eu_2O_3(99.99%).. Weighing was done on highly precise

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balance having accuracy up to four digits that is it measures up to 0.0001gm.Then Europium oxide (Eu_2O_3) was added according to different molar concentration (1,2) mol%. The whole constituents were crushed about 30-35 min until very finely powder was formed. . This combination was transferred to a china crucible, which was then heated in a furnace set at 500°C for 5 hours. The obtained powder was transferred into the mortar pestle and the whole constituent was crushed again about 30-35 min until powder was formed. This mixture was transferred into china crucible and placed it in a furnace, heated in air at 900^0C for 5 hours. After completion of reaction the china crucible was removed from furnace and the sample was grinded for 30 min to obtain fine powder. This sample is now can be used for PL characteristics of ZnB_4O_7.At room temperature, the sample's photoluminescence (PL) emission spectra were measured with a SHIMADZU Spectroflurophotometer (RF-5301 PC) fitted with a 150W Xenon lamp as the excitation source. In each case, the same amount of sample was used.

III. Result and Discussion

3.1 PL characterization of $Zn_4B_6O_{13}$:Eu^{3+} phosphor

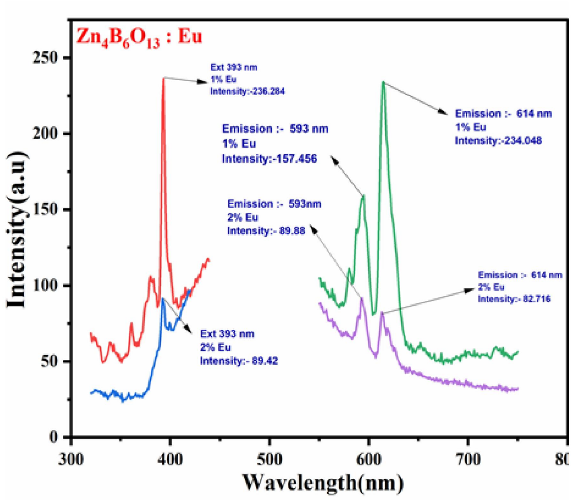

Fig.(1) PL emission and excitation spectra of $Zn_4B_6O_{13}$: Eu^{3+} λ_{exc}= 393nm & λ_{emi}=614nm,593nm

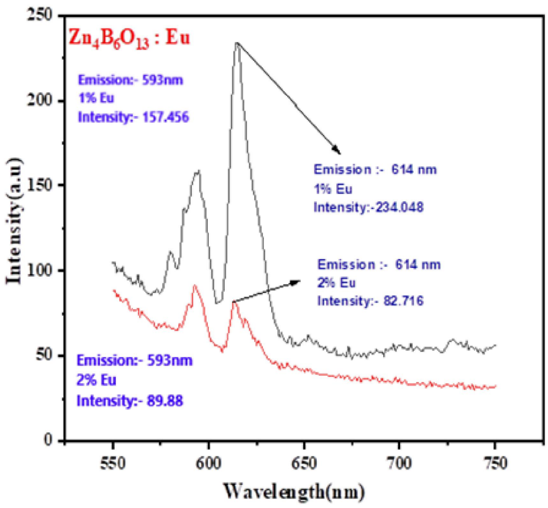

Fig.(2) PL emission spectra of $Zn_4B_6O_{13}$: Eu^{3+} λ_{emi}=593nm,614nm

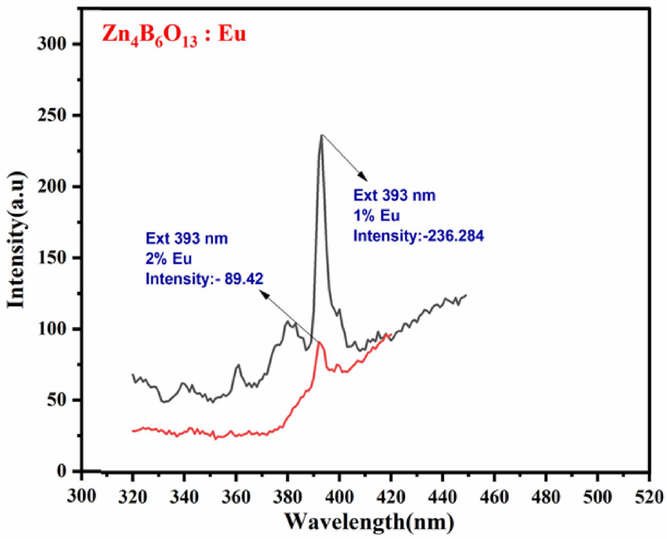

Fig.(3) PL excitation spectra of $Zn_4B_6O_{13}$: Eu^{3+} : λ_{exc}= 393nm

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Table 1: PL emission and excitation spectra of Eu in $Zn_4B_6O_{13}$: Eu^{3+}

Phosphors: - Concentration of Eu^{3+}	PL emission at wavelength (nm)	Intensity (a.u)	PL excitation at wavelength (nm).	Intensity (a.u)
$Zn_4B_6O_{13}$:Eu^{3+}(1mole%)	614 593	234.048 157.456	393	236.284
$Zn_4B_6O_{13}$:Eu^{3+}(2mole%)	614 593	82.716 89.88	393	89.42

Fig (1),Fig.(2) and Fig(3) show the PL spectrum of Eu^{3+} doped $Zn_4B_6O_{13}$ phosphor. In $Zn_4B_6O_{13}$: Eu^{3+} excitation curve shows sharp peaks at 393nm with intensity 236.284 A.U. for 2mole% and 89 A.U. for 1 mole% of Eu^{3+} concentration which is a prominent peak in Eu^{3+} doped phosphors. In PL emission spectrum two peaks are observed one at 593nm and other at 614nm. Emission at 593 nm and 614 may be assigned due to $5D_0 \rightarrow 7F_1$ and $5D_0 \rightarrow 7F_2$ Eu^{3+} transitions in the red-orange zone, respectively. The second (614nm) occurs as a result of a forced electric dipole transition, while the first (593nm) occurs as a result of a magnetic dipole transition. As lighting sources, demand for new materials with low energy consumption and Hg-free lamps is expected. Excitation wavelengths other than 254nm were required for the mercury-free fluorescent lamp.. In our present study shows the excitation of Eu doped $Zn_4B_6O_{13}$phosphor is observed at 393nm.Hence this phosphor is suitable for UV excited red, orange color emitting phosphor in solid state lighting and lamp industry. Further detail study can be done by synthesizing the phosphor for different concentration of Eu^{3+}.X-ray diffraction can be studied for calculation of particle size and various structural parameters of the phosphor under study. Similarly morphological structure can be studied by SEM characterization.

IV. Conclusion

We have synthesized $Zn_4B_6O_{13}$:$Eu^{3+}$by solid state synthesis. The modified solid-state synthesis has several advantages over the other methods. We have studied the photoluminescence characteristics of rare earth $Zn_4B_6O_{13}$: Eu^{3+} phosphors. The PL excitation spectra shows sharp peak at 393nm due to transition of 4f→5d. In the PL emission spectra shoulder peak observed 614nm due to $5D_o \rightarrow 7F_2$ transition of Eu^{3+} ion and other peak is observed at 593nm due to$5D_o \rightarrow 7F_1$. All the characteristics of prepared $Zn_4B_6O_{13}$:Eu^{3+} phosphor shows that this phosphor may be useful for lamp industry (orange and red) and solid- state lighting.

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