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Analysis of Sr2Mg (BO3)2Tb3+ Green Emitting Phosphor for Solid State Lighting: Implication for Light Emitting Diode (LED)

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Abstract

Basically, LEDs have advantages such as a variety of color choices, low electricity consumption, longer service life and even up to 10 years. However, in its development, it is still being carried out to get better quality. With the assist of customized step wise combustion synthesis method Sr2Mg(BO3)2: Tb3+ phosphors were synthesize along with the luminescent proprieties, XRD, chromaticity coordinates with effect of emission intensity with related with the corresponding concentration were studied. The emission spectrum of Sr2Mg(BO3)2 :Tb3+ (x=0.2 to 2 mol %) excited by 353 nm exhibits a strong green emission among peak location at 546 nm is recognized to F-F transitions of Tb3+ 5D4-7F5 ion. This study suggest that Sr2Mg(BO3)2: Tb3+ phosphor be a prominent material as a green constituent for phosphor- transformed W-LEDs for SSL

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INTRODUCTION

Light Emitting Diode (LED) is an electronic component that is currently widely used in human life. The lamp was originally created by Tomas Alfa Edison in the type of incandescent lamp whose shape is still very simple. However, as technology advances, the types and forms of lamps used in everyday life are becoming more and more diverse [1]. One of the lamp brands, namely Philips, has issued products ranging from bulb type lamps, TL lamps (Fluorescent) to the newest Light Emitting Diode (LED) type. While the lamps that are currently most widely used are TL lamps, in addition to the relatively affordable price for the lower middle class, this type of lamp is an Energy Saving Lamp (ESL) because its main working principle is to use gas to produce light, namely fluorescent gas, where it has a cooling effect which reduces heat dissipation [2]. For the type of TL (Fluorescent) there are at least three forms, namely spiral shape, 3U form, and 2U form. Based on these facts, research on the effectiveness of lamps in different types and shapes can be carried out.

According to its excellent applications such as higher performance of luminous, energy-saving capabilities, longer life cycles, and a lack of mercury toxicity, white light-emitting diodes with blue/NUVLEDs are known to produce white light using the next generation [1]. Nichia Co., launches a marketing W-LED with YAG:Ce3+ yellow color

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phosphors covering a blue LED [1], [2]. Since the spectrum emission lacks a red aspect, this white LED is adversely affected by the yellow/blue division and deprived of color - rendering index (CRI) observed. Another technique is to merge various color lights released from various chips to obtain white light. In 1997, Nakamura produced white LEDs by means of three primary common color LEDs (i.e., green as well as blue InGaNSQ W-LEDs with a red AlGaAs LED). However, for such a mechanism, the complex IC control scheme is essential to balance various color degradations between red, green and blue chips. The third loom is made by means of NUV or blue LED sources to stimulate two or tricolor phosphors to provide white light. Lately, in our research group reported some lamp industry applications inorganic phosphors, such as oxides [3], silicate [3], borates [4], tungstate [5], aluminates [6], vanadates [7], halophosphors [8, 9], sulphate [1], [11], phosphates [12], [13] and sulphides [14], [15]. In particular, the absorption performance of phosphors for NUV-LEDs can increase and be subject to visible light in the NUV and high conversion efficiencies. Moreover, the high temperature produced from the LED chip should be resisted by higher thermal consistency. BAM is considered the perfect blue-emitting lamp phosphor because of its higher luminance quality, and strong color perfection under NUV, for the plasma display panels (PDP's) and the fluorescent light and the lighting industries [16]. Due to a huge multiplicity of inorganic compounds with diverse structure, borate mixed phosphor systems are paying more and more attention. These phosphors doped with borate shows outstanding chemical stable phosphor long-lasting time duration with large intensity. These properties are incredibly essential for a variety of industries applications [17]. In this work, a Sr2Mg (BO3)2:Tb3+ phosphor be ready by using customized step wise solid state distribution synthesis methods and prepared phosphor has been well characterized by (XRD) X-ray diffraction, and photoluminescence (PL) analytical techniques with CIE.

METHOD

For the study of the photoluminescence emission as well as excitation spectrum of Sr2Mg(BO3)2: Tb3+ phosphor equipped by means of the assist of customized combustion creation method. These tools integrate higher beams, active emission-wavelengths, rapid fluorescence decay between the constancy of reaction temperature that helps them to detect prominent physical and medical imagery energy [18]. Tb3+, as a green emitting dopant used by light materials, as well as the cross relaxation is one of the characteristic facts of 5D3 to 7FJ transitions and the predominance of both. In addition, some authors documented the green effect of doped Tb3+. Thus Tb3+ is essential in the specific application and in fundamental research together for the spectroscopic property analysis of various materials.

The synthesis of Merck analyzes of inorganic grades of inorganic materials, including Sr[CO3]2 (99.99% purity of the Merck), Mg(CO3) (99.99% purity of the Merck), H3BO3(99.99% purity of the Merck) and cerium nitrate Tb4O7, (Otto, 99.999%), Tb3+ content varies between 0.2 and 02 mol percent, and the processes for modified combustion synthesis continued at around time-suitable for the synthesis of borate compounds. In solid powder shape, the mixture of all the reactions to produce a homogeneous powder with Tb3+ ions were used as Tb4O7.

All components were mixed along with appropriate proportion in mortar and then lastly a pasty combination was produced, after then solution is shift to silica crucible, as well as kept inside muffle furnace set up on a steady temperature 5500C for 10 min duration. The finer powders were extracted from the oven and the substance was once again crushed. The combined precursor powders were carefully mixed and then in the air for 6 hours heated to 6000C. Mixture was heated gradually at 8000C at room temperature for 08 hours after grinding. In addition, fine particles were collected together with further examination for excitation and emission spectrum for PL range, which were then simply milled together with foamy combustion ashes to extract the frothy fines with the blaze.

RESULTS AND DISCUSSION

X-ray diffraction study

A PAN Analytical expert Pro diffractometer XRD diffractometer was used to analyze the XRD contour of the prepared compound with Cu-Kα radiation (1.54060 nm) in the 10.3377 stage time scan form.

The set inorganic phosphor has been synthesized and characterized for its phase purity and crystal structure by x-ray powder diffraction. We have prepared Sr2Mg(BO3)2 materials to explore the XRD contour except that the pure amalgam structure of the crystal phase is formed with the X-ray diffraction blueprint (XRD) test, even though it is novel and amalgamated while retaining the information recognized by the phase pureness control center. The XRD blueprint is like fallows, so that we agree with Ilhan Pekgozluetl's previous work [3]. The XRD demonstrates strong crystal-like materials. Fig.1 displays the XRD blueprint of the Sr2Mg(BO3)2 compound.

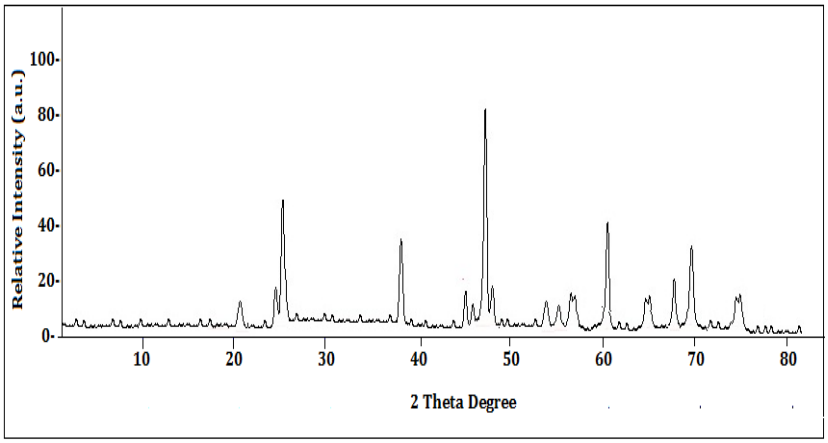

Figure 1. XRD structure of Sr2Mg(BO3)2 phosphor

Photoluminescence Investigation of Sr2Mg(BO3)2 :Tb3+ phosphor

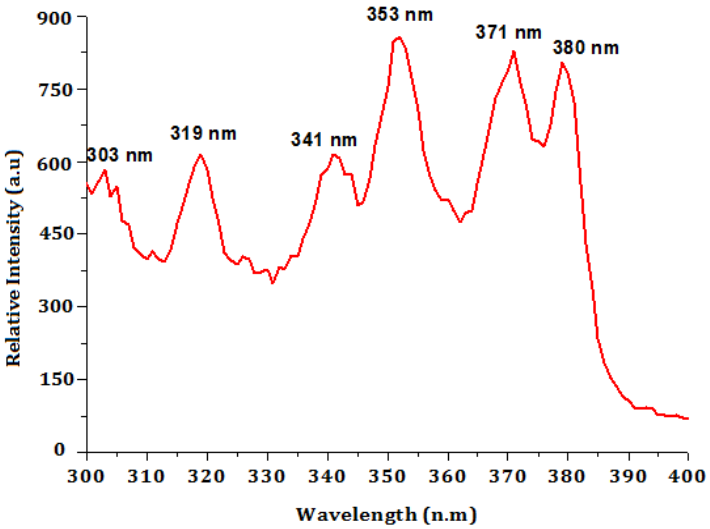

Figure 2. Excitation spectrum of Sr2Mg(BO3)2 :Tb3+ phosphor , λem:- 546 nm

The surveillance of the highest wavelength of Tb3+ green emissions has led to measurement of excitation and emission spectra. We are talking about photoluminescence, namely the emission and excitation spectrum of Sr2Mg(BO3)2, Tb3+ phosphor, as a synthesized example for our research (see Fig. 2). For the entire observed peaks of emission of the prepared phosphor material give an idea about characteristic

emission and excitation of peaks of trivalent lanthanide based ions and the electronic transitions for observable emission peaks [19]. The green emission excitation spectrum of Tb3+ ions reflect various wavelength bands between 300 and 400 nm. We determine the most advantageous compositions with maximum emission intensity by changing the concentration of Tb3+. The peak positions of emission and peak width did not change the concentration of Tb3+ ions. Fig. 3 illustrates the reliance on Tb3+ (5D4-7F5) ion concentration on the green emission intensity measured from the PL emission spectrum. The Sr2Mg(BO3)2 excitement spectrum is shown in Fig. 3 through 5D4-7F5 transition emission tracking at 546 nm.

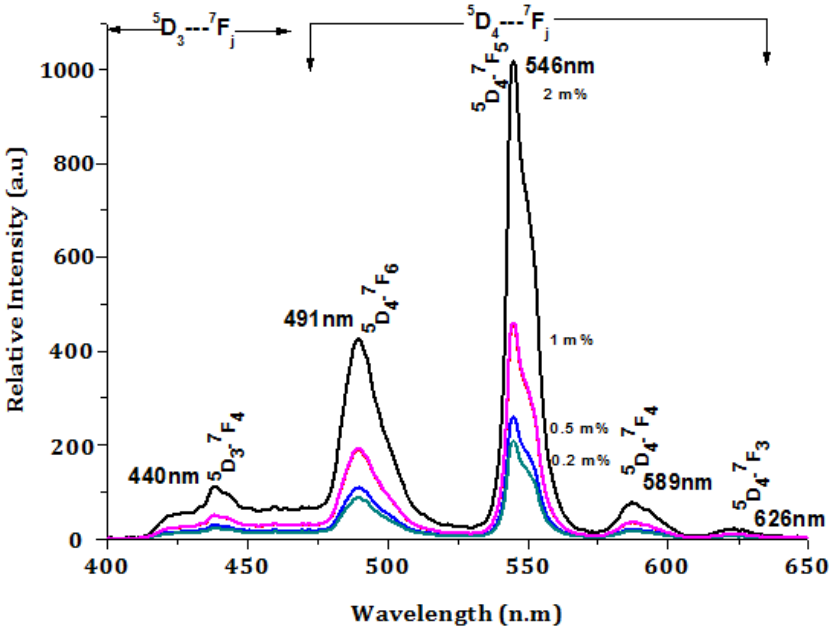

Figure 3. Emission spectrum of Sr2Mg(BO3)2 :Tb3+ phosphor , λex:- 353 nm

A highly green emission of 546 nm (F-F) transitions to tb3+ is the spectrum of Sr2Mg(BO3)2:Tb3+ emissions (x=0.2 to 2 mol percent), which are excited by 353 nm NUV light . The transitions of the energy level in phosphor Sr2Mg(BO3)2 for Tb3+ is shown in Fig. 3. The emission spectrum shows roughly five emission peaks, at 440 nm because of 5D3-7F4, in 491 nm because 5D4-7F6, 546nM because of 5D4-7F5, and in 589 nm as a result of Tb3+ transitions, and 5D4-7F4 and 626 Nm owing to 5D4-7F3. The greatest peak is 546 nm which is suitable for solid lighting and is the strongest green emissions peaks. Excitation band for 546 nm has several excitation bands. One band around 303 nm, 319 nm, 341 nm, 353 nm, 371 nm, and 380 nm respectively. From all the excitation observed we select 353 nm for our study. Owing to the of f-f transition, we observed the emission spectrum shown in Fig 3 shows a few pointed peak of Tb3+ ions. Emission spectrum of prepared phosphor generally has an important peak position part from 5D4–7FJ (J= 6, 5, 4, 3) and as well a peak around 440 nm due to 5D3–7F4 can observed. As observed emission intensity of 5D3-7F4 and 5D4-7F3 is in probable range suitable for solid state lighting. As the Tb3+ concentration changes, the peak of strong green emission at 546 nm will not be affected. Along with rise in Tb3+, the intensity of green emissions is increased at 546 nm. The poor luminescence at 5D3 level is also attributed to the absence of the photonic energy from the host. Seen from the preface of RE ions in luminescent centers into the host material, the luminescent material has improved. Tb3+ion light up to produce powerful visible emissions in the green region. With the assistance of Tb3+ ions, luminescent material is more efficient under UV excitement in many hosts [19], [20]. The aspect that observed is bright Tb3+ aluminums, with a spectrum of emissions consisting of special symmetrical broad emission bands highest at 546 nm, can be helpful for emitting green light to generate white light, is fascinating.

Relationship between Emission Intensity with Concentration of Tb3+ ion in Sr2Mg(BO3)2 phosphor

The series of Sr2Mg(BO3)2 green phosphor was ready and the influence of doping concentration on Sr2Mg(BO3)2 phosphor emission intensity was examined between different Tb3+ concentrations. We illustrate the specimens for each concentration in the graphical manner described above.

Table 1. Intensities of Emission related to Conc. of Tb3+

S.N.	Conc. of Tb_4O_7	Emission intensity(a.u.) in $Sr_2Mg(BO_3)_2$
1	0.2 mol%	245
2	0.5 mol%	285
3	1 mol%	489
4	2 mol%	1115

Tb+ ions in Sr2Mg(BO3)2 of different Tb3+ concentrations (x = 0.2 mol% to 2 mol%) were not concentration-quenched in the trivalent terbium ion and the impact of a Tb3+ doped concentration was examined for emissions intensity. The peak intensity has enhanced by the addition of Tb3+ ions and the maximum intensity has been reported for 2 mol. The Tb3+ and 0.1 mol percent of minimum luminescence intensity have been observed. With the rise of the content of Tb3+ ions, the distance between Tb3+ ions are closer and this gives the ions a greater chance of energy transfer. The peak positions of the emission bands also remain unchanged. Table 04 and Fig. 4 illustrate the effect of Tb3+ in Sr2Mg(BO3)2 and comparative emission intensity.

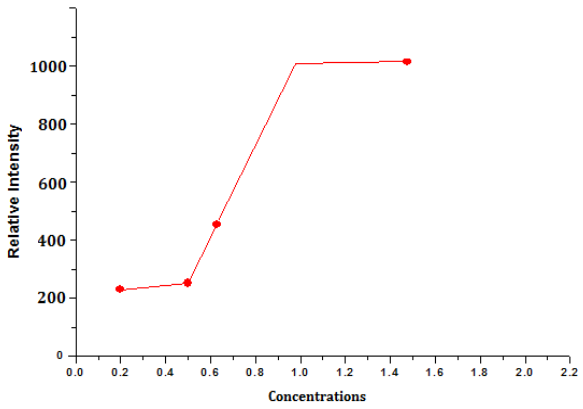

Figure 4. Effect of concentration of dopant (Tb3+ ion) on emission intensity of host lattice.

Chromatic properties of Sr2Mg(BO3)2 Tb3+ phosphor

We consider that Tb3+ ion is there among host material after that the amount of energy be able to shift to activator ion, ensuing as of individual sole release peak in dopant. [20] It is well known that the result is dependent on the attention of dopants for the luminescent properties of as prepared phosphor in fine powder form, so that recognition with the attention of the activator is essential.

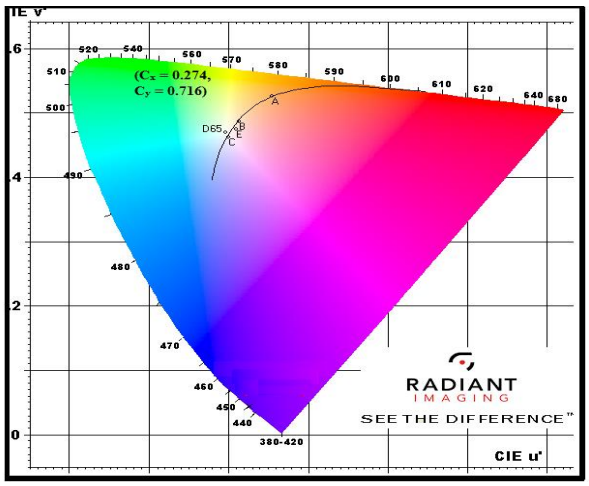

Figure 5. CIE chromatic diagram for Sr2Mg(BO3)2Tb3 phosphor

In this study the emission spectra of Tb3+ in green was selected for additional investigative revise with classification, the properties of Sr2Mg(BO3)2 green emitting inorganic phosphor material which attain the total color emission [20]. The CIE indexed through the Tb3+ spectrum is verified (see Fig. 5). Lighting generally means colors referring to the CIE lighting that the visualization scheme for human beings uses three main shades: red, blue and white [3]-[15]. Sr2Mg(BO3)2: Tb3+ (Cx = 0.274, Cy = 0.716) is shown in Fig. 5. With CIE it is easy to say that Sr2Mg(BO3)2 :Tb3+ are far closer to the CIE graphic case, easy to demonstrate the extreme color clarity of the material being prepared. The results of the excitement by using the emission mechanism, when this tip is combined in a three-angular range between a white light (0.31 and 0.32),] enable the intermediate deal to create a white light between an exhaustive percentage of inorganic green- phosphor [20]. As a result of the growing effects of Tb3+ doped Sr2Mg(BO3)2, which have lovely green emitters that make the prepared green inorganic emitting

phosphor, the prospective material for industrial applications becomes superb [21]–[23]. The spectrum's most critical wavelength is the exceptional light wave longitudinal of the same color as the light source [22]- [24].

CONCLUSION

In this study Sr2Mg(BO3)2: Tb3+ green phosphor emitting. This process enables the formation of very well crystallized particles in excellent fine powder in a tiny portion of quick and energy efficient. A raw green emitting with a peak position at 546 nm is recognized to be the f-f Tb3+ spectrum with the excitement of Sr2Mg(BO3)2:Tb3+ (x=.2 to 2 mol percent) at 353 nm NUV light. The features of Sr2Mg(BO3)2: Tb3+ green emissions clarify that the phosphor preparation material is highly distant in green emission of 0.2 mol% to 5 ml% for Tb3+ phosphor. The CIE co-ordinates clarify with the assistance of emission spectra inspection, the exact location with the CIE index. However, we obtained findings that ready phosphor is likely to function in applications in green lighting sectors. The effect on Sr2Mg(BO3)2 emissions intensity of the concentration of activator Tb3+ is beginning to be significant.

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