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Luminescence Properties of Novel $NaSrB_5O_9:Eu^{3+}$ Phosphor

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Abstract. Europium (III) ions doped $NaSrB_5O_9$ phosphor was prepared first time via a one-step conventional solid state reaction method. The prepared phosphors structure was examined by X-ray diffraction (XRD). It reveals that the undoped and Eu^{3+} doped $NaSrB_5O_9$ phosphors are in single crystalline phase. The room-temperature photoluminescence (PL) spectrum of $NaSrB_5O_9:Eu^{3+}$ phosphor has shown strong red emission at 618 nm ($^5D_0 \rightarrow {}^7F_2$) with near UV an excitation wavelength λ_{exc} = 394 nm ($^7F_0 \rightarrow {}^5L_6$). The calculated color coordinates are lies in the orange region. Therefore, emission and excitation characterization of synthesized phosphor shows that the prepared phosphor may be a promising red component for near ultraviolet white light emitting diodes (NUV WLEDs).

Keywords: Inorganic phosphor; XRD; White LEDs.
PACS: 33.50.Dq, 32.30.Rj

INTRODUCTION

The various inorganic phosphor materials activated with rare earth ions have great attention due to their wide and potential applications in the emerging field of optoelectronics and photonic devices. Currently, much effort have been directed towards white light emitting diodes (WLEDs) owing to their excellent properties such as long lifetime, high durability, low power consumption, high luminescence efficiency and environmental friendliness [1]. With the growing demand of a variety of light sources, the trivalent europium (Eu^{3+} ($4f^6$)) ions doped phosphors show great interest in the orange-red region because Eu^{3+} ions emits narrowband and almost monochromatic light and have long lifetime of the exited states. Therefore, it has been recognized as an efficient red emitter in WLEDs applications [2]. To the best of our knowledge, no results have been reported on the luminescence of $NaSrB_5O_9$ doped with trivalent Eu^{3+} ions. Due to the technological importance of europium ion and the advantages the above research, the Eu^{3+} ions doped $NaSrB_5O_9$ phosphor are prepared and discussed.

EXPERIMENTAL

Polycrystalline samples of undoped and Eu^{3+} (5 at. %) doped $NaSrB_5O_9$ phosphors were synthesized by a solid-state reaction method at high temperature. All the chemicals are of analytical purity Na_2CO_3, $SrCO_3$, H_3BO_3 and Eu_2O_3 (99.99%) were used as received without further purification. First, the stiochiometric mixture of the above mentioned raw materials were thoroughly mixed and ground together in an agate mortar for 1 h. Each of the powder mixtures was put into porcelain crucibles, and was placed in an electric furnace, sintered at 800˚C for 8 h. After sintering, the samples were cooled to room temperature in the furnace, and ground again into powder for further measurements.

The phases of prepared samples were identified by powder X-ray diffraction analyses on a Rikagu X-ray diffractometer - Smart Lab, Japan with CuKα radiation (λ = 1.5406 Å) and the 2θ ranges from 10° to 80°. The luminescent properties of this phosphor were performed using a Jobin Vyon Fluorolog – 3 fluorescence spectrophotometer equipped with a Xenon lamp. All the measurements were recorded at room temperature.

RESULTS AND DISCUSSION

The XRD patterns of activator, Eu^{3+} (0 and 5 at. %) doped $NaSrB_5O_9$ phosphors are shown in Fig. 1. The XRD pattern of $NaSrB_5O_9$ crystal (JCPDS Card No: 56-0415) is also shown in figure for comparison. It is clear from the figure that the Eu^{3+} ions have not caused any significant change after doped into the host lattice structure. Hence, the phosphor prepared by solid state

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reaction method is single crystalline phase without any secondary phases.

Fig. 2 shows the excitation spectrum associated with Eu^{3+} (5 at %) ions in $NaSrB_5O_9$ monitored at 616 nm. The excitation spectrum consists of two parts: one is a broad band from 230 to 290 nm may be attributed to charge transfer band (CTB) of Eu^{3+}, which is peaking at 265 nm, another region comprising several absorption lines from 350 to 550 nm are the intra 4f-4f transition of Eu^{3+} in the host lattice. The sharp intense peaks at 362 nm ($^7F_0 \rightarrow {}^5D_4$), 382 nm ($^7F_0 \rightarrow {}^5L_7$), 394 nm ($^7F_0 \rightarrow {}^5L_6$), 415 nm ($^7F_0 \rightarrow {}^5D_3$), 465 nm ($^7F_0 \rightarrow {}^5D_2$) and 525/533 nm ($^7F_0 \rightarrow {}^5D_1$) are the characteristic transitions of Eu^{3+} ions in host lattice [3]. Among, these several sharp lines, the dominant intense excitation peak lies at 394 nm corresponding to $^7F_0 \rightarrow {}^5L_6$ transition is used to study the emission spectrum for $NaSrB_5O_9$:Eu^{3+} phosphor.

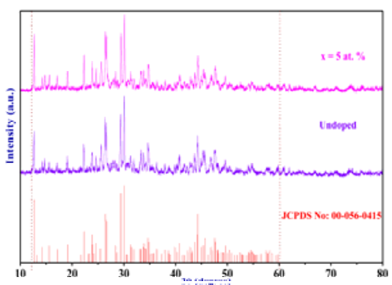

FIGURE 1. XRD patterns of $NaSr_{1-x}B_5O_9$:$Eu^{3+}{}_x$.

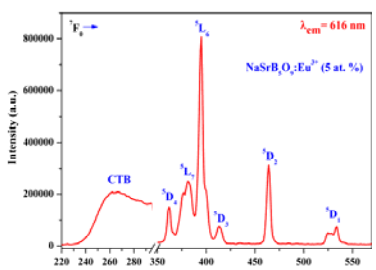

FIGURE 2. Excitation spectrum of $NaSrB_5O_9$:Eu^{3+} (5 at.%).

Fig. 3 shows the emission spectrum of Eu^{3+} doped $NaSrB_5O_9$ phosphor. The emission band covers a region from 550 to 750 nm and it includes several typical emission sub-bands which could be ascribed to the transition from $^5D_0 \rightarrow {}^7F_J$ (J = 1, 2, 3, 4) are the characteristics of Eu^{3+} ions [4]. The emission spectra contain the dominant red emission band at 616 nm is owing to the electric dipole transition of $^5D_0 \rightarrow {}^7F_2$, while the weak emission peak at 592/602 nm is due to the magnetic dipole transition of $^5D_0 \rightarrow {}^7F_1$. Other weak emission bands located at 656 and 693/703 nm could be ascribed to $^5D_0 \rightarrow {}^7F_3$ and $^5D_0 \rightarrow {}^7F_4$ transitions, respectively.

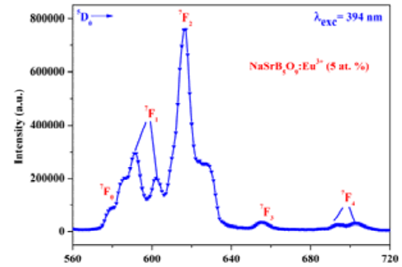

FIGURE 3. Emission spectrum of $NaSrB_5O_9$:Eu^{3+} (5 at. %).

The CIE chromaticity coordinates of the light emission from these Eu^{3+} doped $NaSrB_5O_9$ phosphor excited at 394 nm are depicted in Fig. 4. It indicates that the color of the phosphor with Eu^{3+} ion content lies in the orange region for prepared phosphor.

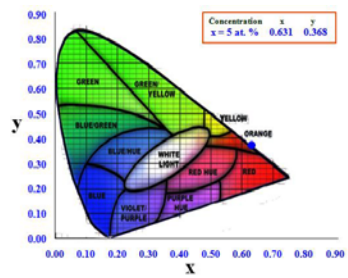

FIGURE 4. CIE color coordinates of $NaSr_{1-x}B_5O_9$:$Eu^{3+}{}_x$.

CONCLUSIONS

In summary, we have successfully synthesized novel and red luminescent $NaSrB_5O_9$:Eu^{3+} phosphor via the high temperature solid-state reaction method. XRD analysis indicates that these phosphor exhibit a single phase. Most importantly, the Eu^{3+} doped $NaSrB_5O_9$ sample exhibits strong red emission at 616 nm ($^5D_0 \rightarrow {}^7F_2$) under the near UV excitation wavelength of 394 nm ($^7F_0 \rightarrow {}^5L_6$). Based on these obtained results, we propose that the newly developed $NaSrB_5O_9$:Eu^{3+} phosphor is a promising candidate as a red component for the fabrication of white LEDs.

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