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Luminescence Properties of Novel NaSrB₅O₉:Eu³⁺ Phosphor

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Abstract. Europium (III) ions doped NaSrB₅O₉ 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 Eu³⁺ doped NaSrB₅O₉ phosphors are in single crystalline phase. The room-temperature photoluminescence (PL) spectrum of NaSrB₅O₉:Eu³⁺ phosphor has shown strong red emission at 618 nm (⁵D₀ → ⁷F₂) with near UV an excitation wavelength λₑₓ = 394 nm (⁷F₀ → ⁵L₆). 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.

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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 (Eu³⁺ (4f⁶)) ions doped phosphors show great interest in the orange-red region because Eu³⁺ 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 NaSrB₅O₉ doped with trivalent Eu³⁺ ions. Due to the technological importance of europium ion and the advantages the above research, the Eu³⁺ ions doped NaSrB₅O₉ phosphor are prepared and discussed.

EXPERIMENTAL

Polycrystalline samples of undoped and Eu³⁺ (5 at. %) doped NaSrB₅O₉ phosphors were synthesized by a solid-state reaction method at high temperature. All the chemicals are of analytical purity Na₂CO₃, SrCO₃, H₃BO₃ and Eu₂O₃ (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.

RESULTS AND DISCUSSION

The XRD patterns of activator, Eu³⁺ (0 and 5 at. %) doped NaSrB₅O₉ phosphors are shown in Fig. 1. The XRD pattern of NaSrB₅O₉ crystal (JCPDS Card No: 56-0415) is also shown in figure for comparison. It is clear from the figure that the Eu³⁺ ions have not caused any significant change after doped into the host lattice structure. Hence, the phosphor prepared by solid state
reaction method is single crystalline phase without any secondary phases.

Fig. 2 shows the excitation spectrum associated with Eu³⁺ (5 at.%) ions in NaSrB₅O₉ 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 Eu³⁺, which is peaking at 265 nm, another region comprising several absorption lines from 350 to 550 nm are the intra 4f-4f transition of Eu³⁺ in the host lattice. The sharp intense peaks at 362 nm (⁷F₀ → ³D₄), 382 nm (⁷F₀ → ³L₅), 394 nm (⁷F₀ → ³L₆), 415 nm (⁷F₀ → ³D₃), 465 nm (⁷F₀ → ³D₂) and 525/533 nm (⁷F₀ → ³D₁) are the characteristic transitions of Eu³⁺ ions in host lattice [3]. Among, these several sharp lines, the dominant intense excitation peak lies at 394 nm corresponding to ⁷F₀ → ³L₆ transition is used to study the emission spectrum for NaSrB₅O₉:Eu³⁺ phosphor.

**FIGURE 1.** XRD patterns of NaSr₁₋ₓB₅O₉:Euₓ⁺.

**FIGURE 2.** Excitation spectrum of NaSrB₅O₉:Eu³⁺ (5 at.%).

Fig. 3 shows the emission spectrum of Eu³⁺ doped NaSrB₅O₉ 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 ³D₀ → ⁷Fₐ (J = 1, 2, 3, 4) are the characteristics of Eu³⁺ ions [4]. The emission spectra contain the dominant red emission band at 616 nm is owing to the electric dipole transition of ³D₀ → ⁷F₂, while the weak emission peak at 592/602 nm is due to the magnetic dipole transition of ³D₀ → ⁷F₁. Other weak emission bands located at 656 and 693/703 nm could be ascribed to ³D₀ → ⁷F₃ and ³D₀ → ⁷F₄ transitions, respectively.

**FIGURE 3.** Emission spectrum of NaSrB₅O₉:Eu³⁺ (5 at.%).

The CIE chromaticity coordinates of the light emission from these Eu³⁺ doped NaSrB₅O₉ phosphor excited at 394 nm are depicted in Fig. 4. It indicates that the color of the phosphor with Eu³⁺ ion content lies in the orange region for prepared phosphor.

**FIGURE 4.** CIE color coordinates of NaSr₁₋ₓB₅O₉:Euₓ⁺.

**CONCLUSIONS**

In summary, we have successfully synthesized novel and red luminescent NaSrB₅O₉:Eu³⁺ phosphor via the high temperature solid-state reaction method. XRD analysis indicates that these phosphor exhibit a single phase. Most importantly, the Eu³⁺ doped NaSrB₅O₉ sample exhibits strong red emission at 616 nm (³D₀→⁷F₂) under the near UV excitation wavelength of 394 nm (⁷F₀→³L₆). Based on these obtained results, we propose that the newly developed NaSrB₅O₉:Eu³⁺ phosphor is a promising candidate as a red component for the fabrication of white LEDs.

**REFERENCES**