

Synthesis, Characterization and Luminescence Properties of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ Phosphor

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$\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor was prepared at high temperature by solid state method. The phase structure of phosphor was characterized as double perovskite structure. The cell parameters of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ were determined as $a = 8.361 \text{ \AA}$, $b = 8.288 \text{ \AA}$, $c = 8.211 \text{ \AA}$, $\alpha = \beta = \gamma = 89.78^\circ$. The luminescence properties were studied. The results revealed that Eu^{3+} ions show red emission about 616 nm.

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1. Introduction

Tungstate crystals have been widely studied for their application as phosphors and scintillators. The most investigated compounds are CaWO_4 and MgWO_4 (as phosphors), as well as ZnWO_4 , CdWO_4 , and PbWO_4 (as scintillators) [1]. The intrinsic luminescence of tungstate crystals comes from annihilation of a self-trapped exciton, which forms the excited WO_4^{2-} and WO_6^{6-} complex for sheelite and wolframite crystal, respectively. Moreover, they may also effectively transfer energy to rare-earth ions Eu^{3+} generating red emission, thus becoming potential white-light phosphors. One of the approaches to obtain white light is to combine a UV LED/laser diode with blue, green, and red (BGR) phosphors [2, 3]. CaWO_4 was first used as luminescent material in 1896, and due to a possibility of self-activation, it became a high-efficiency material emitting blue light under X-ray, electron-beam, and UV irradiation. First investigations on the rare-earth-activated tungstates were reported in the sixties by Blasse, Bril and Borchardt [4, 5]. Crystals of potassium lanthanide double tungstates and molybdates were reported by Kaminskii to be efficient luminescent hosts for rare-earth and transition-metal ions [4]. The phonon properties of $\text{KEu}(\text{MO}_4)_2$ ($\text{M} = \text{Mo}, \text{W}$) were described by Macalik [6]. Very extensive studies of the optical properties of double rare-earth molybdates and tungstates of the composition $\text{MRE}(\text{XO}_4)_2$ ($\text{M} = \text{Cs}, \text{K}, \text{Rb}$; $\text{RE} = \text{rare earth}$; $\text{X} = \text{Mo}, \text{W}$) were also reported [7]. Promising luminescence properties of $\text{Eu}_2(\text{WO}_4)_3$ were well investigated by Kodaira et al. [8]. Sr_2ZnWO_6 has been widely studied mainly due to their unusual and interesting physical properties including ferroelectric, dielectric and magnetic properties, etc. [7, 9]. The photoluminescence properties of $\text{Sr}_{2-2x}\text{Eu}_x\text{Na}_x\text{ZnWO}_6$ ($\text{Sr}_2\text{ZnWO}_6:\text{Eu}^{3+}$) were studied. $\text{Sr}_2\text{ZnWO}_6:\text{Eu}^{3+}$ exhibits strong absorption in near ultraviolet region, and shows the bluish-green emission in visi-

ble region. After substituting Eu^{3+} ions for Sr^{2+} ions, the red emission is observed except for the bluish-green emission, and thus $\text{Sr}_{2-2x}\text{Eu}_x\text{Na}_x\text{ZnWO}_6$ is a potential phosphor for the full-color LEDs [10].

To our knowledge, the photoluminescence properties of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ have not been studied. This report describes the synthesis, characterization and luminescence properties of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor.

2. Experimental

The $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor was prepared by using conventional ceramic method [7, 8]. The starting materials were SrCO_3 , WO_3 and Eu_2O_3 . Proper amounts of the initial materials were weighted, and grounded in an agate mortar. The grounded powders were heated for 6 h at 1350°C .

Phase purity was examined by using a Bruker, D8 Advance X-ray diffractometer (XRD) with $\text{Cu } K_\alpha = 1.54 \text{ \AA}$ radiation. Photoluminescence (PL) measurements were carried out on a Varian Cary Eclipse Fluorescence Spectrophotometer.

3. Results and discussion

The phase purity and phase structure of prepared sample were characterized by the X-ray powder diffraction (XRD) patterns. As is known, Sr_3WO_6 has a double perovskite structure [11]. The positions of diffraction peaks (see in Fig. 1) in the prepared sample are in accordance with those of the JCPDS No. 21-1193. The cell parameters of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ has been determined as $a = 8.361 \text{ \AA}$, $b = 8.288 \text{ \AA}$, $c = 8.211 \text{ \AA}$, $\alpha = \beta = \gamma = 89.78^\circ$.

The excitation spectra of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ is shown in Fig. 2. The excitation peaks at 307 nm and 393 nm are attributed to electronic transition of Eu^{3+} ions ($4f^6 \rightarrow 4f^5 5d^1$).

The emission spectrum shows four emission peaks which are placed at 595, 616, 653, and 708 nm, respectively (Fig. 3). These peaks belong to ${}^5D_0 \rightarrow {}^7F_j$ ($j = 0 \div 4$) transitions of Eu^{3+} ions (616 nm: ${}^5D_0 \rightarrow {}^7F_2$

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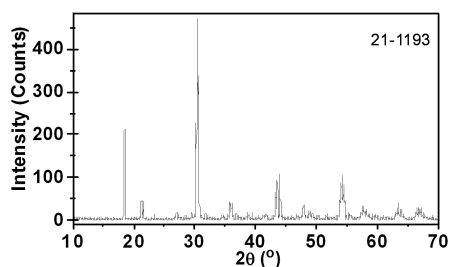


Fig. 1. The XRD pattern of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor (JCPDS File No: 21-1193).

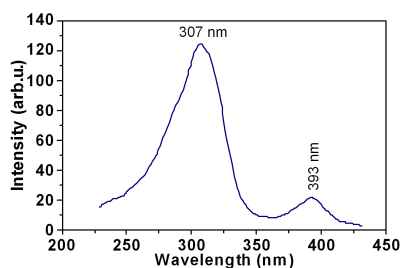


Fig. 2. The excitation spectra of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor.

and 595 nm: $^5D \rightarrow ^7F_1$). Generally, the Eu^{3+} emission arises mainly from the 5D_0 excited level to the 7F_j ($J = 1, 2, \dots$) ground levels of the $4f^6$ configuration. The emission intensity corresponding to the electric dipole $^5D_0 \rightarrow ^7F_2$ transition is larger than that of magnetic dipole $^5D_0 \rightarrow ^7F_1$ transition. This result indicates that the symmetry around Eu^{3+} does not contain an inversion center [10].

The luminescence decay curve of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor is shown in Fig. 4. The luminescence decay curve was measured by 616 nm emission wavelength intensity. The decay time was analysed by a curve fitting technique based on the following equation:

$$I = A \exp(-t/\tau), \quad (1)$$

where I is luminescence intensity, A is a constant, t is the time, τ is luminescence decay time for the exponential components, respectively.

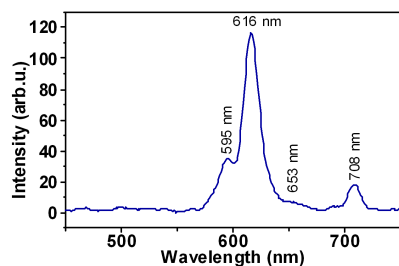


Fig. 3. The emission spectra of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor.

The decay time value of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor was determined as 6.59 ms and can be seen in Fig. 4.

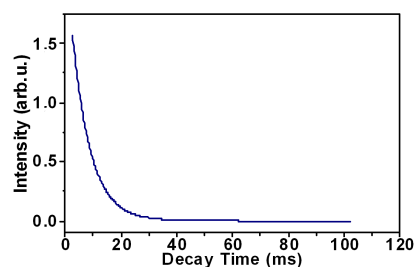


Fig. 4. The luminescence decay curve of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor.

Conclusion

$\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor has been prepared at high temperature by a solid-state reaction method. The crystal structure of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor has been determined as double perovskite structure with $a = 8.361 \text{ \AA}$, $b = 8.288 \text{ \AA}$, $c = 8.211 \text{ \AA}$, $\alpha = 89.78^\circ$. The excitation spectra of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor show that two excitation bands. The excitation bands at 307 and 393 nm are assigned to the electronic transition of Eu^{3+} ions. The emission spectra of $\text{Sr}_3\text{WO}_6:\text{Eu}^{3+}$ phosphor exhibit four emission bands, which are attributed to the $^5D_0 \rightarrow ^7F_j$ ($j = 0 \div 4$) transitions. The luminescence decay curve has been fitted by single exponential decay and the decay time is calculated as 6.59 ms.

References

- [1] A.A. Blistanov, B.I. Zadneprovskii, M.A. Ivanov, V.V. Kochurikhin, V.S. Petrakov, I.O. Yakimova, *Phys. Prop. Cryst.* **50**, 284 (2005).
- [2] A.A. Kaminskii, *Laser Crystals their Physics, Properties*, Springer, Berlin 1981.
- [3] V. Pankratov, L. Grigorjeva, D. Millers, S. Chernov, A.S. Voloshinovskii, *J. Lumin.* **94**, 427 (2001).
- [3] A.A. Blistanov, B.I. Zadneprovski, M.A. Ivanov, V.V. Kochurikhin, V.S. Petrakov, I.O. Yakimova, *Crystallogr. Rep.* **50**, 284 (2005).
- [4] G. Blasse, A. Bril, *J. Chem. Phys.* **45**, 2350 (1966).
- [5] H.J. Borchardt, *J. Chem. Phys.* **39**, 504 (1963).
- [6] L. Macalik, *Pol. J. Chem.* **69**, 286 (1995).
- [7] S.J. Patwe, S.N. Achary, M.D. Mathews, A.K. Tyagi, *J. Alloys Comp.* **390**, 100 (2005).
- [8] C.A. Kodaira, H.F. Brito, O.L. Malta, O.A. Serra, *J. Lumin.* **101**, 11 (2003).
- [9] M. Gatheshki, J.M. Igartua, E. Hernandez-Bocanegra, *J. Phys. Condens. Matter* **15**, 6199 (2003).
- [10] X. Zhang, Z. Li, H. Zhang, S. Ouyanga, Z. Zoua, *J. Alloys Comp.* **469**, L6 (2009).
- [11] G. King, A.M. Abakumov, J. Hadermann, A.M. Alekseeva, M.G. Rozova, T. Perkisas, P.M. Woodward, G.V. Tendeloo, E.V. Antipov, *Inorg. Chem.* **49**, 6058 (2010).