Structural and Photoluminescence Properties of Eu^{3+} doped $BaZrO_3$ Phosphors: Effect of two synthesized temperatures.

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Abstract

In this work, the down conversion (DC) behaviour of Eu^{3+}(1, 3, 5, 7, 9, 10 &12 mol%) ions doped in $BaZrO_3$ have been investigated. The samples were synthesized by solid-state reaction method. All prepared phosphor samples were heated at two different temperatures (i.e., 873K & 1473K). The samples were structurally and morphologically characterized by x-ray diffraction (XRD) and scanning electron microscope (SEM) measurements. The vibrational behaviour of the phosphor samples was investigated by Fourier transform infrared (FTIR) measurements. All the phosphors emit intense red emission at 595 nm ($^5D_0 \rightarrow {}^7F_1$) & 613 nm ($^5D_0 \rightarrow {}^7F_2$) transition of Eu^{3+} ion under the excitation with 296, 314, and 393 nm wavelength. The PL emission intensity at 595 nm and 613 nm are increased with increasing Eu^{3+}concentrations. PL emission intensity is optimized at concentration of 9mol%Eu^{3+} ions and further emission intensity decreased at higher concentration. Simultaneously, emission intensity of defect level decreased. This material can be a potential red emitting phosphor for UV-based white LED and other display devices.

Introduction

The investigations on rare earth-based inorganic phosphors have attracted intensive scientific interest because of their excellent emission features, which have wide applications in display devices, light emitting diodes (LEDs), solar cells, finger print sensing, bi-imaging, optical heaters, etc. They exhibit strong brightness, long term stability, and comparatively faster response behavior [1–6]. Extensive research has been carried out on rare earth ion-activated oxide based phosphor materials due to their excellent structural, chemical, and thermal stability and wide applications. In the rare earth ions, the 4f-4f intra-band electronic transitions result in narrow band emissions with a relatively longer lifetime. Their partially filled 4f electrons are shielded by filled 5s and 5p electrons, due to which their intraband 4f-4f transitions are less affected by external fields [7]. The Eu^{3+} ion is an important activator among the rare-earth ions, which shows a narrow band of intense red emission at 613 nm due to the $^5D_0 \rightarrow {}^7F_2$ transition. The red luminescence from Eu^{3+} ions has potential applications as LEDs, sensors for testing the asymmetry of a host, etc. The rare earth-doped calcium zirconate phosphor materials have been widely investigated in recent years due to their low phonon frequency. It shows good electrical, thermal, mechanical, and optical properties.

Design/Other information

Solid-State Reaction method :

The stoichiometric amount of raw materials was mixed homogeneously in an agate mortar using AR grade acetone as the mixing media. After homogeneous mixing, the mixture was placed in an alumina crucible and calcined at a high temperature furnace at an optimized temperature 873 K for 5 h and a part of these samples further heated at 1473K .

Set up

❑ **Structural characterization techniques:**
1. X-ray Diffraction Technique (XRD)
2. Scanning Electron Microscopy (SEM)

❑ **Optical techniques:**

1. Fourier Transform Infrared Spectroscopy

Frontier series, Perkin Elmer

Dept. of Physics BHU

2. UV-Vis-NIR Absorption Spectrometer

Lambda 750, Perkin Elmer

3. Photoluminescence Measurement

Fluorolog 3-11 , Horiba Jobin Yvon

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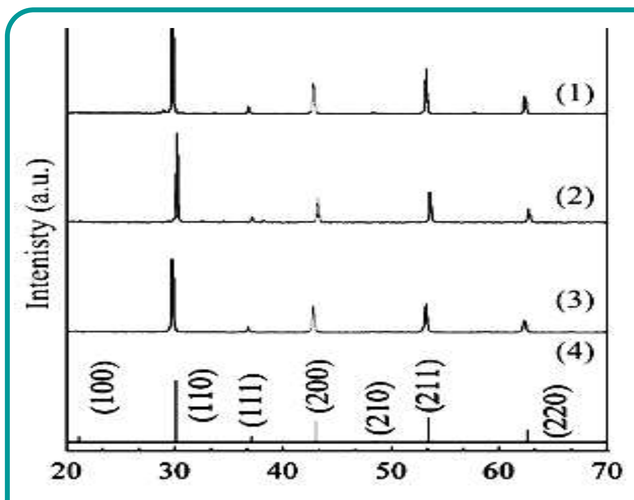
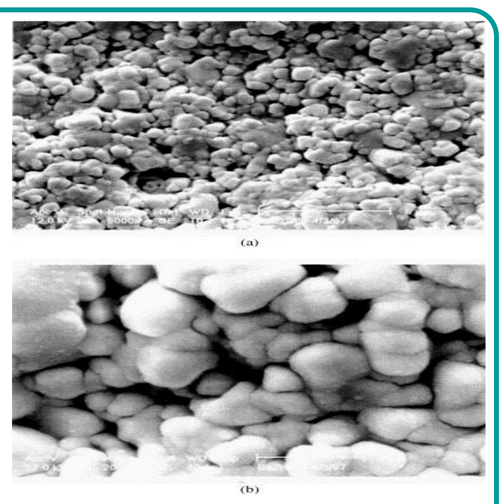
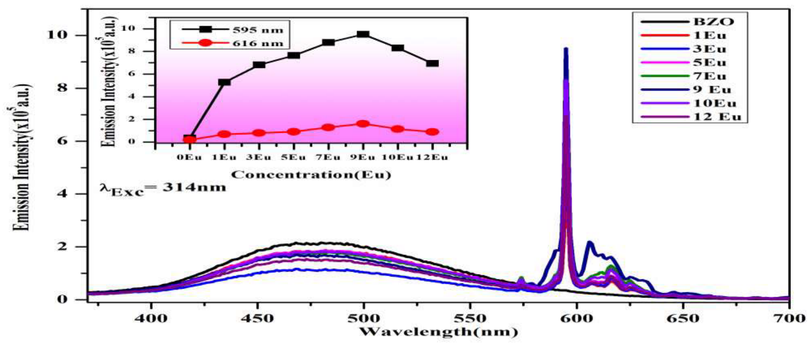
Results







Conclusions

All the phosphors emit intense red emission at 595 nm ($^5D_0 \rightarrow {}^7F_1$) & 613 nm ($^5D_0 \rightarrow {}^7F_2$) transition of Eu^{3+} ion under the excitation with 296, 314, and 393 nm wavelength. The PL emission intensity at 595 nm and 613 nm are increased with increasing Eu^{3+}concentrations. PL emission intensity is optimized at concentration of 9mol%Eu^{3+} ions and further emission intensity decreased at higher concentration. Simultaneously, emission intensity of defect level decreased. This material can be a potential red emitting phosphor for UV-based white LED and other display devices.

References

[1]S. K. Singh, A. K. Singh, S. B. Rai, Efficient dual mode multicolor luminescence in a lanthanide doped hybrid nanostructure: a multifunctional material, Nanotechnology 22 (2011) 275703-275712.
[2] A. Maurya, R. S. Yadav, R. V. Yadav, S. B. Rai, A. Bahadur, Enhanced green upconversion photoluminescence from Ho3+/Yb3+ co-doped CaZrO3 phosphor via Mg2+ doping, RSC Adv. 6 (2016) 113469-113477.
[3] M. Rai, S.K. Singh, A. K. Singh, R. Prasad, B. Koch, K. Mishra and S. B. Rai, Enhanced Red Upconversion Emission, Magnetoluminescent Behavior and Bioimaging, Mater. Interfaces 7 (2015) 15339-15350.
[4] L. Guo, Y. Wang, J. Zhang, Y. Wang and P. Dong, Near infrared quantum cutting in Ho3+, Yb3+ co-doped BaGdF5 nanoparticles via first and second-order energy transfers, Nanoscale Research Lett. 7 (2012) 636-642.
[5] R. G. A. Kumar, S. Hata, K. Ikedad, K. G. Gopchandran, Organic mediated synthesis of highly luminescent Li+ ion compensated Gd2O3:Eu3+ nanophosphors and their Judd–Ofelt analysis, RSC Adv. 6 (2016) 67295-67307.
[6] A. Dwivedi, K. Mishra, S. B. Rai, Role of Gd3+ ion on downshifting and upconversion emission properties of Pr3+, Yb3+ co-doped YNbO4 phosphor and sensitization effect of Bi3+ ion, J. Appl. Phys. 120 (2016) 043102-043114.
[7] P. Singh, P.K. Shahi, S.K. Singh, S.B. Rai, Photoluminescence, upconversion and quantum-cutting emission in Tm/Tb/Pr and Yb co-doped oxide phosphor: A comparative study, J. Alloys and Comp. 681 (2016) 477-485.

International Conference on
Composite Materials for Environment Protection & Remediation
(ICCMEPR - 2024) 02-03 July, 2024