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Effect of doping Dy3+ ions concentration on the structural, photoluminescence and thermo luminescence properties of Ba1. 3Ca0.7SiO4 phosphors for lighting application

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ABSTRACT
In this study, single-phase Ba1.3Ca0.7SiO4: x mol%Dy3+ (x = 0-5) phosphors were prepared by solution combustion method. X-ray diffraction pattern showed that the Ba1.3Ca0.7SiO4: x mol%Dy3+ phosphors are polycrystalline with predominant hexagonal T-phase structure. The scanning electron microscope images show that the synthesized nano powder consists of small particles in the order of few microns that are uniformly distributed over the surface having clear grain boundaries but changed to spongy shape morphology at the high content of Dy3+ ions. The ultraviolet-visible analysis displayed that the percent reflectance in the UV-region to be dependents on Dy3+ concentration. The estimated optical bandgap varies between 3.60 and 3.85 eV. The Chen method was used to analyses the TL kinetics of the two glow peaks observed at 409K and 523K for the samples doped with a different molar concentration of Dy3+. Photoluminescence spectra revealed strong emissions at 482 and 576 nm and weak once at 710 nm which were assigned to 4F9/2 →6H15/2, 13/2, 11/2 transitions of Dy3+ ions, respectively. The CIE color coordinates confirmed that the luminescence color of Ba1.3Ca0.7SiO4: Dy3+ was tuned from blue to white with an increase in the Dy3+ molar content.

Key words: E microscope, UV-region, Photoluminescence

INTRODUCTION

In this study, Ba1.3Ca0.7SiO4: Eu^{3+} red-orange phosphors were synthesized by the solution combustion method. The effect of varying Eu^{3+} molar percentages on the material properties including its intrinsic quantum efficiency (IQE) was investigated. XRD results showed synthesized phosphor is hexagonal T-phase Ba1.3Ca0.7SiO4 and the average crystallite size calculated using the Scherer's formula was estimated to be ~33 nm. SEM result showed the synthesized Ba1.3Ca0.7SiO4: Eu^{3+} phosphor had granular shaped and slightly agglomerated particles. The EDS shows that prepared samples contain Ba, Ca, Eu, Si, and O as expected. UV–vis measurement confirms the percent reflectance in the UV- region to be dependents on Eu^{3+} ions and the estimated bandgap vary between 3.80 and 4.23 eV. Photoluminescence emission measurements of all prepared samples at room temperature appeared to be entirely from inter configurational Eu^{3+} emission and depend both on the site symmetry as well as ion concentration. Hence, the peak centred at 592 nm is due to transition $^5D0 \rightarrow ^7F1$, while the peak centred at 615 nm is due to transition $^5D0 \rightarrow ^7F2$. The quadrupole-quadrupole multipolar interaction was found to be exclusively responsible for luminescence quenching. The Judd-Ofelt intensity parameters (Ω2, Ω4), asymmetry ratio (R0), and average decay lifetime of the nanocrystals showed dependence on concentration. High IQE values were obtained at low Eu^{3+} ion concentrations but the efficiency decreased with increasing ion concentration. The CIE color coordination confirmed that the emitted color fall in the strong orange-red region of the emission spectrum. Eu2+-doped and Eu2+/Mn2+-codoped Ba1.3Ca0.7SiO4 phosphors were synthesized by means of a conventional solid-state reaction process. The single-phase purity was checked by means of X-ray diffraction and the Rietveld method. Under excitation at 390 nm, the emission spectra of the Eu2+-doped phosphors exhibit a broad-band emission centered at 500 nm caused by the electric dipole allowed

transition of the Eu2+ ions. The emission spectra of codoped phosphors show one more broad emission centered at 600 nm attributable to the transitions from the 4T1(4G) → 6A1(6S) of Mn2+ ions. The luminescent color of the codoped phosphors can be easily adjusted from blue to red with variation of the Mn2+ content. The energy transfer mechanism from the Eu2+ to Mn2+ ions in Ba1.3Ca0.7SiO4 phosphors has been confirmed to be the resonant type via dipole–quadrupole interaction, and the critical distance has been calculated quantitatively. All these results demonstrate that the Eu2+/Mn2+-codoped Ba1.3Ca0.7SiO4 phosphors can be a promising single-phase, color-tunable phosphor for near-UV white-light-emitting diodes after a further optimization process. Additionally, a great red shift from 593 to 620 nm has been observed following the increase of Mn2+ content, and the phenomenon has been discussed in relation to the changes in the crystal field surrounding the Mn2+ ions and the exchange interactions caused by the formation of Mn2+ pairs.

A new ceramic τ- Ba 1.31 Ca 0.69 SiO 4 :0.02Dy $^{3+}$ phosphors synthesised by solution combustion technique and its photoluminescence properties were examined. XRD confirmed that the average crystal size of the synthesised powders was 41.27 nm. SEM measurement displayed that phosphor contain agglomerated particles having clear grain boundaries. EDS reveal that all expected elements such as Ba, Ca, Dy, Si, and O were appeared. UV–Vis measurement showed defuse reflectance and energy band gap of prepared material. FTIR measurement confirmed that strong absorption band appeared at 838.20cm $^{-1}$. Photoluminescence measurement detected that intense peak emission observed at 483 nm and 576 nm is due to Dy $^{3+}$ ions dopant. This revealed that white light emission is due to the Dy $^{3+}$: ^{4} F 2/9 → ^{6} H 15/2 and Dy $^{3+}$: ^{4} F 9/2 → ^{6} H 13/2 transitions in the spectrum region (460 −500 nm) and (550 nm – 600 nm) respectively. The CIE color coordinates calculated from the emission spectra to simulate white light emission.

The thermoluminescence (TL) properties of barium silicate phosphor, Ba2SiO4:%3Dy3+ synthesized by using hydrothermal method were investigated and presented in detail. The crystallographic structure of Ba2SiO4:%3Dy3+ was determined by conventional x-ray diffraction technique and the results showed that the sample was grown in orthorhombic phase with Pmcn (62) space group (PDF: 01-077-0150). The excitation spectra of Ba2SiO4:Dy3+ were measured in the wavelength range of 220-400 nm and the spectra showed that there were several excitation bands in the sample. The CIE chromaticity coordinates were also calculated from emission spectra for Dy3+-doped Ba2SiO4. In order to calculate the kinetic parameters of the sample the additive dose, peak shape and computerized glow curve deconvolution methods were used. It was found that Ba2SiO4:Dy3+ was composed of five general order TL glow peaks. The fading characteristics of the sample were also studied over a period time. At the end of the planned storage times, the normalized TL peak area of Ba2SiO4:Dy3+ reduced 60% of its original value.

REFERENCES

[1]. Li H. H.; Yin S.; Wang Y. H; Sato T. Microwave-Assisted Hydrothermal Synthesis of Fe2O3-Sensitized SrTiO3 and its Luminescent Photocatalytic deNOx Activity with CaAl2O4:(Eu, Nd) Assistance. *J. Am. Ceram. Soc.*, **2013**, 96, 1258-1262.
[2]. Kim J. S.; Sung H. J.; Kim B. J. Photocatalytic characteristics for the nanocrystalline TiO2 on the Ag-doped CaAl2O4:(Eu,Nd) phosphor. *Appl. Surf. Sci.*, **2015**, 334, 151-156
[3]. Meng Y. Z.; Shen Y.; Hou L. Y.; Zuo G. F.; Wei X. L.; Wang X. M.; Li F. F. Study on photocatalysis and dynamics properties of self-catalysis BiVO4 assembled in porous Sr2MgSi2O7:Eu2+,Dy3+. *J. Alloy Compd.*, **2016**, 655, 1-5.
[4]. Kim J. S.; Sung H. J.; Jung S. C. Synthesis of the TiO2-Long Lasting Phosphor (Sr4Al14O25:Eu2+,Dy3+) Composite and its Photocatalytic Reaction Properties. *Ceram. Environ. Syst.*, **2016**, 257, 23-33.
[5]. Li G.; Tian Y.; Zhao Y.; Lin J. Recent progress in luminescence tuning of Ce3+ and Eu2+ -activated phosphors for pc-WLEDs. *Chem. Soc. Rev.*, **2015**, 44, 8688-8713..