Photoluminescence behavior of rare-earth ion (Eu^{3+})doped cerium oxide

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Abstract.-Rare-earth ion (Eu) doped CeO_2 phosphors were prepared by the modified solid state reaction method, which is the most suitable for large-scale production. Sample was characterized by X-ray diffraction (XRD) and crystallite size was determined by using well known scherrer equation. The optical studies of samples have been done by photoluminescence (PL) emission and excitation spectra which was recorded in room temperature. The PL emission was observed in the range 592, 612 and 633 nm range. The effect of different concentration of Eu in optical study is reported in present paper.

Keywords: Rare-earth doped phosphor, Photoluminescence (PL), solid state method, XRD,

I. INTRODUCTION

Rare earth doped phosphors have gained a great attention as a efficient luminescent materials because of its electronic and optical properties and are found in a broad range of display application such as LED, fluorescent light (FL), electro-luminescent panel (EL), and field emission display [1-5]. Rare earth doped oxides possess electronic transition due to the 4f-4f transition of activator ion which exhibits high luminescence. CeO_2 is widely used for catalyst, gas sensor and UV-protective coating[6-9]. Mainly its application in solid oxide fuel cells which operate at low temperature range (400-700^oC) such as oxygen sensor [10], have been the centre of attraction due to its oxygen storage capacity [11].Trivalent cerium ($^4f_1$) possesses parity allowed 4f–5d electronic transitions and due to the large energy gaps, non-radiative decay is less likely to occur and 5d emission can beobserved whereas in case of tetra valent [$^4f_0$] cerium, absorption belongs to character of charge transfer and has no luminescence [12]. This paper reports synthesis of CeO_2 doped with Europium concentration (0.1, 0.2 and 0.5 mol%) by solid state reaction method which is suitable for large scale production and eco-friendly method. The prepared sample was characterized by XRD, photoluminescence studies as well as particle size was calculated by Debye-Scherer formula.

II. EXPERIMENTAL

The Eu^{3+} doped CeO_2phosphors were prepared via high temperature modified solid state reaction. The mixture of reagents were ground into a fine powder with an agate mortar -pestle, for 45 minutes, to ensure the best homogeneity and reactivity and heated in a muffle furnace at 1250 °C for 2 hr [13]. The sample was characterized at the Inter University Consortium (IUC) Indore for X-ray diffraction. XRD data were collected over the range 20–70˚ at room temperature. The XRD measurements were carried out using a Bruker D8 Advance X-ray diffractometer. The X-rays were produced using a sealed tube, and the wavelength of the X-ray was 0.154 nm (Cu K-alpha). The X-rays were detected using a fast counting detector based on silicon strip

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III. RESULT AND DISCUSSION

XRD

The XRD pattern of CeO_2: Eu^{3+} phosphor is shown in fig.1. According to the X-ray diffraction peaks sample is havingcubic fluorite CeO_2crystal structure. The crystallite size of the samplewas computed using the Scherrerequation $D = 0.9 \lambda / \beta \cos \theta$ where λ=0.154nm represents the wavelength of X-ray, θ is the diffraction angle and β represents the FWHM of diffraction peak. The average crystallite size of prepared phosphor was found 27 nm.

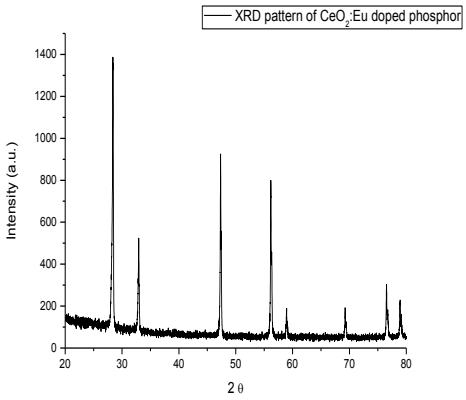

Fig.1. XRD pattern of CeO_2:Eu doped phosphor

Photoluminescence (PL) properties

Fig.2 shows the Excitation spectrum of CeO_2:Eu^{3+} that recorded by monitoring the $^5D_0 \rightarrow {}^7F_1$ transition of Eu^{3+} at 592 nm emission, which exhibits excitation band in the range of 280– 400 nm is caused by the charge transfer state (CTS) originating from interaction between $Ce^{4+}$and O^{2-}.

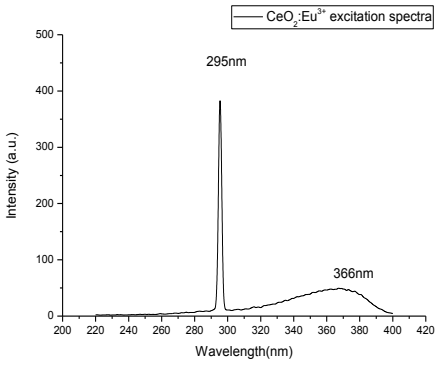

Fig.2. excitation spectra for CeO_2:Eu^{3+} phosphors with 592 nm excitation

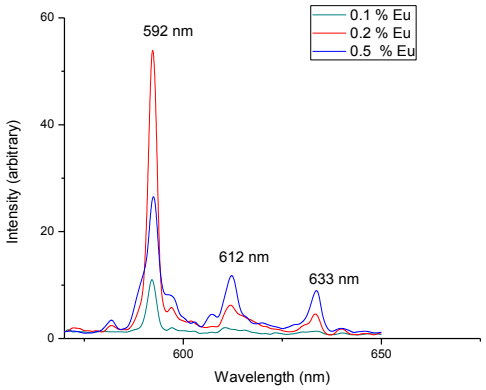

Fig.3. PL emission spectra of CeO_2:Eu^{3+}phosphors

Fig.3 shows the emission spectra of CeO_2:Eu^{3+} (0.1, 0.2 and 0.5 mol%) phosphors recorded at 550 – 633 nm range under 366 nm excitation and it has been concluded that these phosphors exhibit orange – red emissions and useful for display devices application. For all samplesonly one dominant emission peak of Eu^{3+}occurred due to the magnetic dipole transition $^5D_0 \rightarrow {}^7F_1$ at 592 nm and twoother weak emission peaks were found at 612 and 633 nm corresponding to the electric dipole transition $^5D_0 \rightarrow {}^7F_2$ and $^5D_0 \rightarrow {}^7F_3$.For 0.2 % concentration of Eu thehighest emission intensitywas observed and exceeding this concentration it was found that the dominant emission intensity decreased which may cause by concentration quenching.

IV. CONCLUSION

It is concluded that the phosphor was prepared by solid state reaction method using concentration of dopant as (0.1, 0.2 and 0.5 mol%). The sample was characterized by XRD technique and Photoluminescence study. The crystallite size of prepared phosphor found to be in nano range 27 nm calculated by debye-scherrer formula. The PL study concluded that 0.2 % Eu containing phosphor under 366 nm excitationgives comparatively an intense orange emission at 592 nm.

V. ACKNOWLEDGEMENT

Authors are very thankful to Dr. K.V.R. Murthy for carrying out photoluminescence study.

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