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GAMMA RAY INDUCED THERMOLUMINESCENCE PROPERTIES OF $ZrO_2:Eu^{3+}$, Dy^{3+} PHOSPHOR

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ABSTRACT

The present paper reports the synthesis, characterization and Gamma dose induced thermoluminescence properties of $ZrO_2:Eu^{3+}$, Dy^{3+} phosphor. The sample was prepared by solid state reaction method. The particle size of prepared phosphor was calculated by XRD technique and Confirmed by Scanning electron microscope. The luminescence property of prepared phosphor examined by thermoluminescence technique and Computerized Deconvolution method was applied to obtain the deconvoluted curve. For recording TL glow curve 0.5mg phosphor was irradiated by 0.5 kGy gamma radiations at $3^{\circ}Cs^{-1}$ heating rate. Trapping parameters were calculated for deconvoluted TL glow curve.

Keywords: $ZrO_2:Eu^{3+}$, Dy^{3+} Phosphor, XRD, SEM, Gamma radiation, Thermoluminescence, Deconvolution.

I. INTRODUCTION

Semiconductors and insulator materials like Zirconium, are remarkable materials due to their excellent mechanical, electrical, thermal and optical properties. Recently, nanoparticles have been recognized to take potential in the area of photonic applications [1-11]. Some researches have done on thermoluminescent properties of zirconium oxide based phosphors. Zirconia can adopt three different crystalline structures: cubic, tetragonal, and monoclinic, depend on the synthesis temperature [4,6]. Only few research works has been done on the thermoluminescence properties of this material. In the present work, face centered crystalline phase of ZrO_2 was successfully synthesized by simple solid state reaction method [5,8] and its thermoluminescence property was investigated. The synthesized phosphor's structural characterizations were done by using powder X-ray diffraction (PXRD) and scanning electron microscopy (SEM). To the best of our knowledge, no thermoluminescence (TL) studies on $ZrO_2:Eu^{3+}$, Dy^{3+} phosphor have been reported for gamma dose. Europium and dysprosium are good dopents for optical properties [12] The thermoluminescence studies were carried out using TLD reader I1009 supplied by Nucleonix Sys. Pvt. Ltd. Hyderabad [13]. The heating rate used for TL measurement is 3°C/s. Computerized glow curve deconvolution was applied on the TL glow curve and kinetic parameters were calculated by using Chen's peak shape method [14].

II. SYNTHESIS OF ZrO_2: Eu^{3+}, Dy^{3+}

The conventional solid state reaction process is used to prepare the ZrO_2:Eu^{3+}, Dy^{3+} phosphor. Oxide of zirconium, europium and dysprosium with high purity (sigma Aldrich 99.99%) were mixed in stoichiometric ratio by dry grinding in mortar & pestle for nearly 60 minutes. The mixture is taken in quartz boat and is fired in air at 1200°C for 2 hours in presence of boric acid as a flux. We prepared the phosphor with fix concentration of Eu^{3+} and Dy^{3+} at 1mol%. Finally ZrO_2:Eu^{3+}, Dy^{3+} phosphor were obtained by solid state reaction method [11, 15-19].

III. RESULT AND DISCUSSION

3.1 Structural Characterization

Fig.1 shows the XRD patterns of the ZrO_2: Eu^{3+}, Dy^{3+}. Diffraction peaks are well matched with ICCD card no. 89- 9069 showing a face centred cubic structure [11]. The size of the crystal has been computed from the full width half maximum (FWHM) of the all peaks using the Scherer's formula $d=k\lambda/\beta Cos\theta$ [20]. Where, D is the average crystal size perpendicular to the reflecting planes, k is the constant the value of K is .89, λ is the X-ray wavelength, β is the FWHM, and θ is the diffraction angle. The particle size of the sample is found around 77nm.

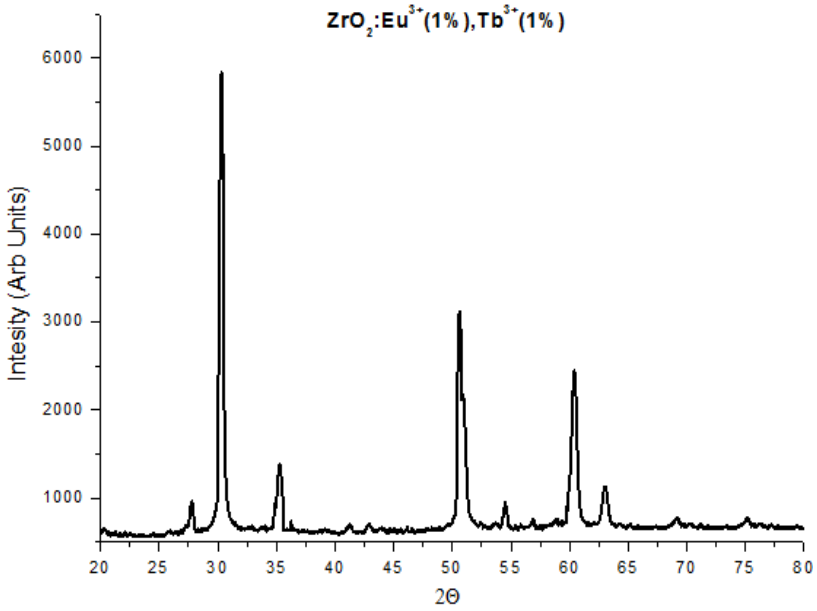

Fig 1 X-ray diffraction pattern of ZrO_2: Eu^{3+}(1%), Dy^{3+}(1%)

3.2 Scanning Electron Microscope (Sem)

Figure 2 shows SEM images of prepared phosphors. As this figures shows, the grain size of ZrO_2: Eu^{3+}, Dy^{3+} near to the XRD results.

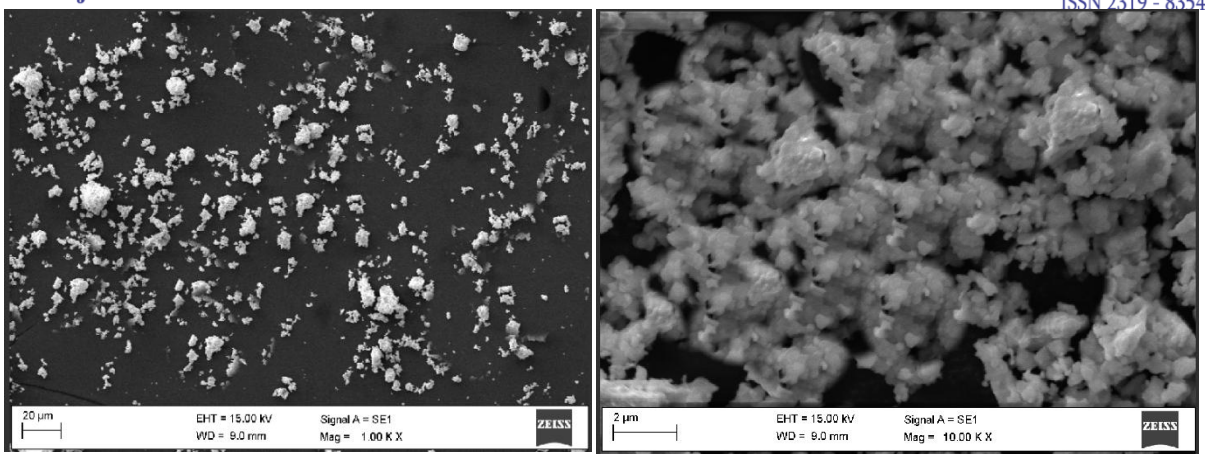

Figure 2. SEM image of ZrO_2: Eu^{3+}(1%), Dy^{3+}(1%)

3.3 Thermo Luminescence Studies

Thermoluminescence glow peak of ZrO_2:Eu^{3+}; Dy^{3+} has been recorded under 0.5kGy gamma dose. The glow peak was recorded for 3°Cs^{-1} heating rate. The deconvoluted glow peak was found at 129°C 186 °C and 236 °C (Fig 3).

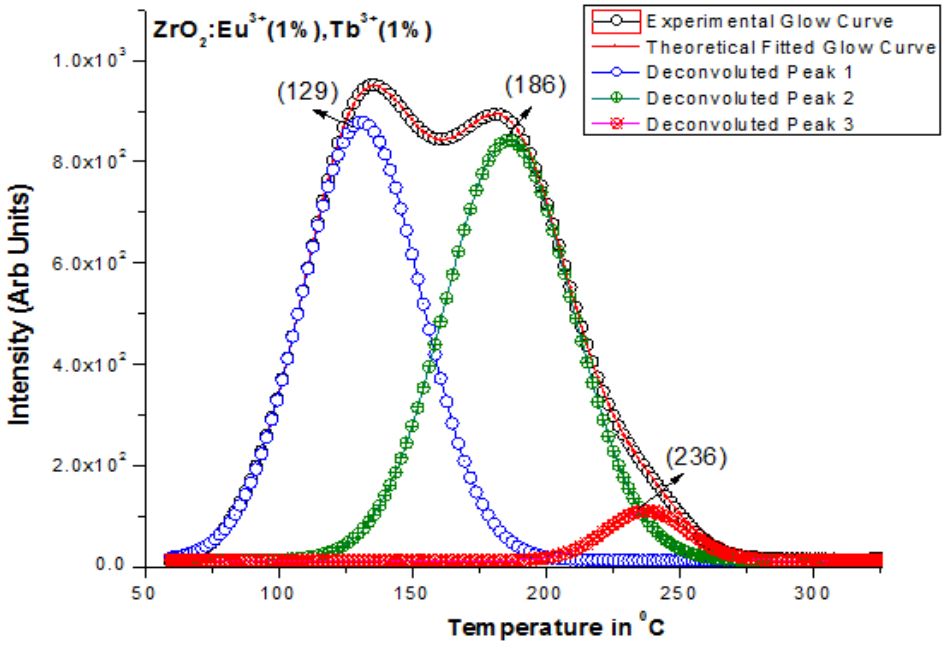

Figure 4. Deconvoluted TL glow curve of ZrO_2:Eu^{3+} (1%) Dy^{3+} (1%) for .5kGy gamma ray

Table 1 shows the evaluated kinetic parameters of prepared phosphor. Kinetic parameters determination has always been an active area of research for better understanding of the TL mechanism [21-29]. The trap depth and the frequency factor of isolated peaks were evaluated using the Chen's peak shape method and others [14, 22, 30-32].

Table :- 1 Kinetic parameters for $ZrO_2:Eu^{3+}$(1%), Dy^{3+} (1%)

Peak	T_1	T_m	T_2	τ	δ	ω	μ =δ /ω	Activation Energy (E)	Frequency Factor (s^{-1})
Peak 1	104	129	159	25	30	55	0.545	0.848	7.2×10^{11}
Peak 2	157	186	215	29	29	58	0.5	0.942	3.16×10^{11}
Peak 3	218	236	255	18	19	37	0.514	1.874	8.45×10^{19}

IV. CONCLUSIONS

The ZrO_2: Eu^{3+}(1%), Dy^{3+} (1%) phosphor was synthesized by simple solid state reaction method. The characterization by XRD shows the sample was cubic in structure with 77 nm crystal size. The particle size was confirmed by SEM images. Sample shows good TL response and the kinetic parameters are also evaluated shows the second order of kinetics for deconvoluted three peaks. The activation energy is found in the range of 0.848 to 1.874 and frequency factor (s) in the range of 3.16×10^{11} to 8.45×10^{19} s^{-1}.

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