Advance Physics Letter

Deconvoluted Thermoluminescence Glow Curve of $Y_2O_3:Gd^{3+}$ Under UV Excitation

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Abstract: Gadolinium doped Y_2O_3 phosphor was synthesized by using solid state reaction method. Prepared phosphor was characterized by using powder X-ray diffraction pattern and field emission gun scanning electron microscopy (FEGSEM). XRD pattern confirms cubic phase of prepared phosphor which has particle size of 50 nm and confirms with SEM image. Thermoluminescence glow curve was recorded under 254 nm UV excitation under $6°Cs^{-1}$. The thermoluminescence behaviour of the prepared phosphor was analyzed by applying computerized glow curve deconvolution (CGCD). All the trapping parameters were determined by using peak shape method for deconvoluted TL glow curve.

Key words: $Y_2O_3:Gd^{3+}$, X-ray diffraction, Scanning electron microscope, Thermoluminescence, CGCD.

I. INTRODUCTION

Yttrium sesquioxide (Y_2O_3) has been an important material in the ceramic industry, from being a constituent of ceramic super- conductors to well-known YSZ ceramics [1]. It also plays an important role in the preparation of novel light emitting materials.Y_2O_3 is an advanced ceramic due to its stable physical and chemical properties, which has been widely used as a host material in various luminescent applications. It also presents the advantage of highly saturated color, which makes it a promising material for various industrial applications [2-4]. It may also used as Thermoluminescencedosimeter.

Thermoluminescence dosimeters are the materials used to measure the ionizing radiation dose. Thermoluminescence is process of emission of photons (in the visible range) from a pre-irradiated insulator or a semiconductor materialunder thermal stimulation [5-7].The thermoluminescence phenomenon occurs when the semiconductor material is exposed to ionizing radiation. A fraction of free electrons or holes are produced due to the exposure or radiation and they may be trapped by defects named as traps present within the crystal lattice of the prepared phosphor materials. If the traps are deep enough means the requirement of energy is too higher, the trapped charges may remain in those sites for an extended period of time. As the material is heated by external source, the trapped charges may escape from the trapping centers and then recombine with other trapped charges with opposite sign. The emission of light, so called thermo luminescent-signal occurs during the recombination process. Although many natural minerals are thermo luminescent, the most efficient TL materials are almost always formulated synthetic materials. There are two main reasons: first, theirthermo luminescent signal is proportional to the radiation dose delivered and second, synthetic materials usually show reproducibility in their response. Moreover, for calibration, a linear relationship between the TL signal and the absorbed dose is desirable[8-10].

II. EXPERIMENTAL:

The Gd^{3+} doped Y_2O_3phosphor was prepared via high temperature solid state reaction method. The Y_2O_3, Gd_2O_3were used as precursor materialsand ultra pure Boric acid was used as a flux for the preparation of gadolinium doped Y_2O_3. According to stoichiometric amountsin molar ratio were used to prepare $Y_2O_3:Gd^{3+}$ (1%) phosphor. Themixture wastaken in alumina crucible and fired in presence of air at 1300°C for 4 hour in a muffle furnace [11,12].

The structural characterization was done by using XRD, and FEGSEM. The XRD measurements were carried out using Bruker D8 Advance X-ray diffractometer. The X-rays were produced using a sealed tube and the wavelength of X-ray was 0.154 nm (Cu K-alpha). The X-rays were detected using a fast counting detector based on Silicon strip technology (Bruker Lynx Eye detector).Observation of particle morphology was investigated by FEGSEM (field emission gun scanning electron microscope) (JEOL JSM-6360). The thermoluminescence behaviour of the prepared phosphor was determined by recording TL glow curve by using the TLD reader. Thermoluminescenceglow curves were recorded at room temperature by using TLD reader I1009 supplied by Nucleonix Sys. Pvt. Ltd.Hyderabad. The obtained phosphor under the TL examination is given UV radiation using 254nm UV source [11-15].

III. RESULTS AND DISCUSSION:-

3.1 X- Ray diffraction:- (XRD)

The prepared phosphor materials were analyzed by PXRD to reveal phase compositions and the particle size (Fig 1). The crystallite size was calculated from the PXRD pattern following the Scherer equation d= kλ/βCosθ [17-19]. Here, k = 0.89 constant, dis the crystallite size for the (hkl) plane, λ is the wavelength of the incident X-ray radiation [CuKα(0.154 nm)], β is the full width at half maximum (FWHM) in radians, and θ is the diffraction angle for the (hkl) plane. From the PXRD pattern, it was found that the prominent phase formed is pure Y_2O_3 and diffraction peaks as well indexed based on the international centre for data diffraction (ICDD) no. 89-5591. This reveals that the structure of Y_2O_3 is cubic. The prepared phosphor was having particle size in the range of 50 nm.

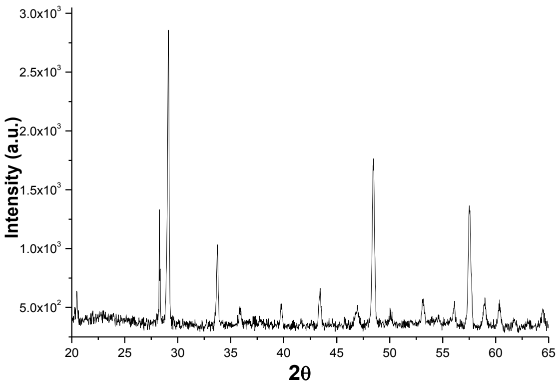

Figure 1. Powder XRD pattern of Y_2O_3: Gd^{3+} (1%) doped phosphor [11,12]

3.2 Scanning Electron Microscope (SEM):

The morphology of the Y_2O_3:Gd^{3+} was determined by using SEM technique (Fig 2). The SEM image confirms the formation of nano sized particles of the prepared sample. It also shows good morphology and connectivity with grains.

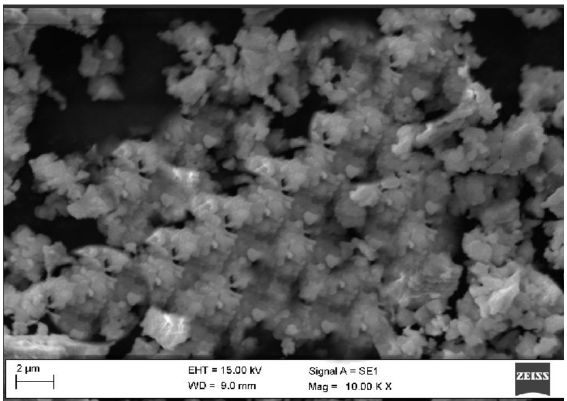

Figure 2. SEM images of prepared Y_2O_3: Gd^{3+} (1%) phosphor

3.2 Thermoluminescence glow curve under 254 nm UV excitation:

The TL glow curve of Y_2O_3:Gd^{3+} was obtained after irradiating the sample under 254 nm UV exposures for 10 min under 6°Cs^{-1} heating rate. The TL glow curve has single glow peak at 94°C. Effect of UV exposure on TL glow curve has been determined [4, 11-12].

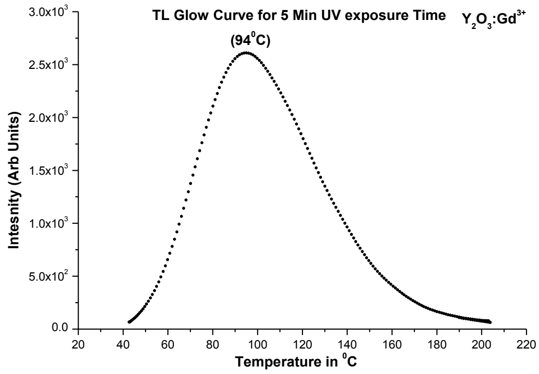

Figure 3. TL glow curve of Y_2O_3:Gd^{3+} phosphor for 5 minutes UV exposure time

3.3 Computerized Glow Curves Deconvoluted (CGCD) analysis of thermoluminescence glow curve of Y_2O_3:Gd^{3+} phosphor

The computerizedglow curves deconvoluted (CGCD) and the theoretical curve fitted with the experimental curve for optimized conditions is recorded for nanocrystalline powder samples exposed to UV radiation (Fig.5). Trapping parameters are calculated for the deconvoluted peak. From the data it is clear that all the peaks follow second order of kinetics and hence there is no re-trapping takes place[20-35].

Kinetic parameters quantitatively describe the trapping-emitting centres responsible for the TL emission. Therefore, determination of the kinetic parameters is an active area of research for better understanding of TL process. The kinetic parameter for deconvoluted glow peak have been calculated by using Chen's peak shape method [5,9,36-37].The activation energy for peak 1 is 0.734 eV and for peak 2 it is 0.611eV. The value of shape factor is around 0.5 which is near to 0.52 so the results confirm the presence of second order kinetics for all the TL glow peaks (Table 2).

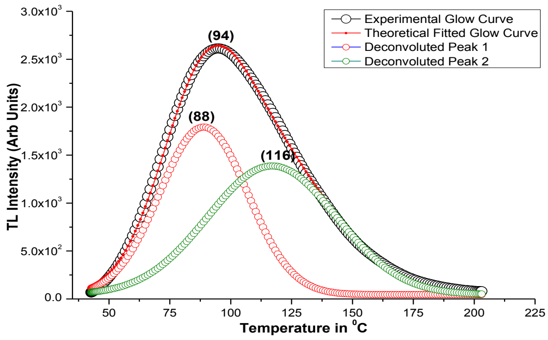

Figure 5. Computerized glow curve deconvolution of TL glow curve of Y_2O_3:Gd^{3+}(1 mol%) phosphor for 15 minutes UV exposure time.

Table 1. Typical trapping parameters of the deconvolution peaks of Y_2O_3:Gd^{3+}

	T_1 (^0C)	T_m (^0C)	T_2 (^0C)	μ_g	E (eV)	S (s^{-1})
Peak 1	65	88	111	0.5	0.734	3.26×10^{11}
Peak 2	84	116	148	0.5	0.611	1.09×10^{09}

IV.CONCLUSION

Y_2O_3:Gd^{3+} was synthesized by using conventional solid state reaction method. TL behaviour under gamma radiation was recorded and shows TL glow peak at 234ºC. Effect of gamma dose shows continuous increase in intensity. Value of shape factor is found in between 0.48 to 0.51 which is nearly equal to 0.52 which shows second order kinetics. The value of frequency factor is in between 1.17×10^9 to 3.6×10^9.

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