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Elementary Result TL and OSL Properties of $LiBaPO_4:Tb^{3+}$ Phosphor

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Abstract— *The crystalline sample of $LiBaPO_4:Tb^{3+}$ was successfully synthesized by a solution combustion method and has been studied for its thermo-luminescence (TL) and optically stimulated luminescence (OSL) properties. Formation of the compound was confirmed by x-ray diffraction pattern that matched with ICDD files. The TL glow curve of the $LiBaPO_4:Tb^{3+}$ has a simple structure with a single peak at 231^0C. TL sensitivity of the $LiBaPO_4:Tb^{3+}$ phosphor for beta ray is found 1.5 times sensitive than of TLD-500.while, In CW-OSL mode sensitivity of $LiBaPO_4:Tb^{3+}$ phosphor is 50% more than that of the commercial available α-Al_2O_3:C.*

Keywords— *Solution combustion method; TLD-500; CW-OSL; beta-ray.*

PACS Code— *78.60.Kn, 78.60.Lc*

1. INTRODUCTION

Optically stimulated luminescence (OSL) is a relatively new technique in dosimetry of ionizing radiations. In OSL, the defects are stimulated by the light in the visible/IR region and as a result, release of either the electron or hole. The released ions are captured at the recombination centre leads to emission of radiation, generally at a shorter wavelength compared to the wavelength of the stimulating radiation. The general requirement for material to be a good OSL phosphor is that the emission should be between 350 and 425 nm and the defects should have strong photo-ionization cross-section in blue green-region (450–550 nm) or IR region (650–800 nm). This limit on wavelength is due to availability of suitable filters, stimulation sources as well as sensitive photo multiplier tubes in this range. Most importantly, the requirement of separation of stimulating wavelength from the emission wavelength ensures better signal to noise ratio. OSL was firstly used in archeological dating [1] and after development of Al_2O_3: C the technique has attracted researchers to use in personnel and environmental monitoring [2]. In recent years, many OSL phosphors where synthesized by using different synthesis technique like high temperature solid state reaction and co-precipitation method [3-5]

To our knowledge, Tb-doped $LiBaPO_4$ phosphor synthesis by using combustion method and its OSL properties under beta irradiation has not been reported in the literature. In addition, there have been no published results concerning the complete TL and PL studies of this phosphor material.

In present work, we first time reports luminescence properties of $LiBaPO_4:Tb^{3+}$ by using combustion synthesis reaction.

2. EXPERIMENTAL

The polycrystalline sample $LiBaPO_4:Tb^{3+}$ was prepared by the combustion synthesis method. The raw materials high-purity $Li(NO)_3$, $Ba(NO_3)_2$, $NH_4H_2PO_4$ and $Tb(NO_3)_3{\cdot}5H_2O$ were used. The materials were mixed according to the formula $LiBa_{(1-x)}PO_4:_xTb^{3+}$. In the process of synthesis all the precursor materials were mixed in china basing crucible and adding small amount of double distilled water, to get paste. The paste was kept on hot plates and we get a complete clear solution from the paste. As prepared clear solution then transferred to the pre heated furnace maintained at 500^0C to 550^oC. After warming it for 5 min the self redox reaction was completed and the fine white powder of $LiBaPO_4:Tb^{3+}$ phosphor. As prepared sample was the heated in the furnace at 850^0C for near about 2hr to remove the excess of impurities left during the reaction.

As synthesized host samples were then subjected to the XRD analysis on Rigaku miniflex X-ray diffractometer with scan speed of 2.000 deg./min and with Cu-Kα radiation. For studying the TL and OSL response, the samples were irradiated using $^{90}Sr/^{90}Y$ beta source with the dose rate of 20 mGy per minute. The CW-OSL studies were carried out using RISO TL/OSL system. The TL studies were done by using indigenously made PC based TSL reader with the heating rate $4^0C/S$ developed by BARC, Mumbai.

3. RESULT AND DISCUSSION

3.1 XRD-Studies

Figure 1 shows the XRD pattern of the $LiBaPO_4:Tb^{3+}$ synthesized by using solution combustion method. It can

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be observed that the XRD pattern of prepared sample is in good agreement with the ICDD data file (ICDD Card No. 00-014-0270). Important lines in ICDD pattern for the 2θ value at 28.83^0C for highest intensity were in exactly matching with experimental data. This agreement indicates that $LiBaPO_4$:Tb^{3+} has been successfully prepared by using the solution combustion method.

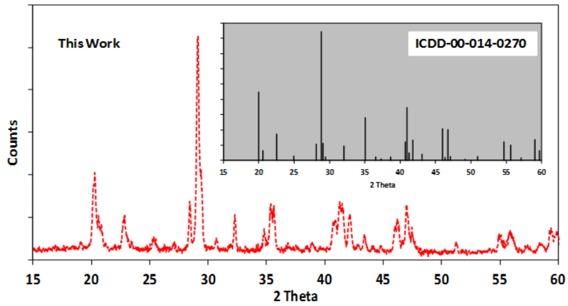

Fig. 1: XRD Pattern of Tb^{3+} doped LiBaPO4 with standard ICDD file

3.2 Thermoluminescence

Figure 2 represent the thermo-luminescence glow curves of $LiBaPO_4$ doped with Tb^{3+} rare earth ion. During this study sample was exposed to 20mGy of β-ray radiation. TL glow curve of $LiBaPO_4$:Tb^{3+} phosphor observed in temperature range 50 to 350°C and sensitivity of material is compared with commercial TLD-500. The phosphor found 1.5 times sensitive than TLD-500 (Al_2O_3: C).

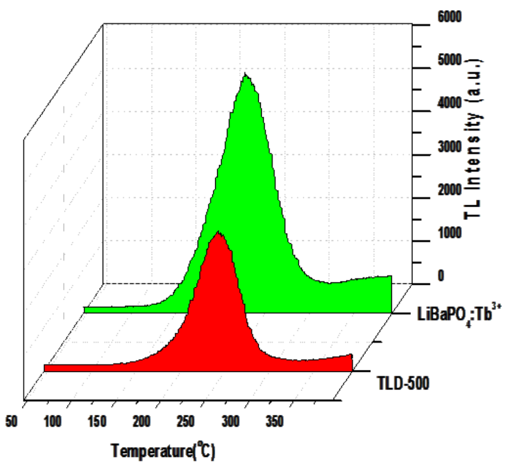

Fig. 2: TL response of $LiBaPO_4$:Tb^{3+} phosphor compared with TLD-500 under 20mGy of beta source

Figure 3 show deconvoluted curves of $LiBaPO_4$: Tb^{3+}. TL glow curves was deconvoluted by using Peak Fit software and kinetic parameters such as activation energy (E) and frequency factor (s) of the glow peak were calculate by using convenient peak shape method [6-7]. From geometrical factor (μg) it has been confirmed that the glow peaks follow the second order of kinetic. The calculated activation energy and frequency factor is shown in table 1.

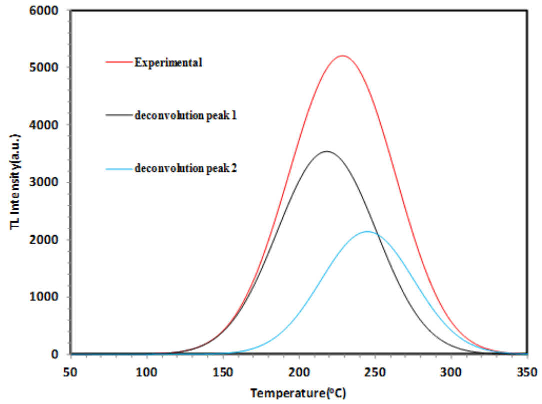

Fig. 3: Deconvolution of glow peak LiBaPO4:Tb^{3+} phosphor exposed to beta ray radiation

Table 1: Kinetic parameter of $LiBaPO_4$:Tb^{3+}

Phosphor	*Peak*	*Order of kinetics*	*E (eV)*	*s (S^{-1})*
$LiBaPO_4$:Tb^{3+}	I	Second	0.87	1.75×10^8
	II	Second	1.04	3.35×10^9

3.3 Optically Stimulated Luminescence

The sample was studied for its OSL response using blue LED stimulation (470 nm).

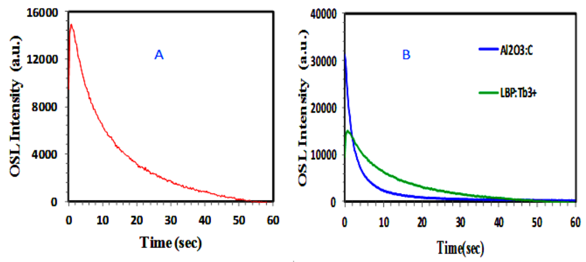

Fig. 4: (a) CW-OSL response of $LiBaPO_4$:Tb^{3+} for 60 sec.; (b) CW-OSL response compared with commercially α-Al_2O_3:C

Figure 4(a) shows the typical CW-OSL response of $LiBaPO_4$:Tb^{3+} for 20mGy beta dose. Figure 4(b) represents the comparison of OSL sensitivity for beta exposure was found to be 50 % compared to commercial available α-Al_2O_3: C.

4. CONCLUSION

The solution combustion method was successfully employed for the preparation of new TLD and OSLD potential phosphor. The XRD profile of $LiBaPO_4$:Tb^{3+} was found to show good agreement with the ICDD File. The comparison of TL and OSL sensitivity shows $LiBaPO_4$:Tb^{3+} was 1.5 times sensitive than that of TLD-500 and 50% sensitive than commercially available α-Al_2O_3:C, respectively. The phosphor can be proposed as a suitable candidate for radiation dosimetry, after further progress in the study.

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