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Luminescence Characteristic of LiMgBO3 Phosphor

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ABSTRACT

The present paper reports the combustion synthesis of $LiMgBO_3$ phosphor with Dy and Mn dopants. During the combustion synthesis we have used Dy and Mn activators so as to explore the possible compound for TL glow curve analysis and their application for TL dosimetry. The combustion synthesis method, though tricky but it is very simple and time saving method. This work deals with detail procedure for synthesis of $LiMgBO_3$ phosphor with Dy and Mn dopants. We have also studied their TL glow curve analysis and luminescent characteristics for TL dosimetry. Preparation of Lithium Borate host materials is tricky work. The synthesis is not straightforward. We became successful in synthesizing few mixed borate compounds by combustion synthesis method. Thermoluminescence studies were carried out on all the possible combinations of $LiMBO_3$:Re (M = Mg, Ca, Sr, Ba & Re = Ce, Eu, Dy, Mn). The TL sensitivity of $LiSrBO_3$:Dy is comparable with the $CaSO_4$:Dy. We have successfully achieved the 71% TL sensitivity in this phosphor however it has high Z_{eff} value because of Strontium. Whereas the TL peak temperature was found to be 178°C, lower than that of $CaSO_4$: Dy.

Keywords: LiMgBO, combustion method, TL intensity, TL

I. INTRODUCTION

Borate compounds are known for their wide band gap, strong nonlinear optical properties, chemical and environmental stabilities and mechanical robustness. They are the best hosts for various activators. From the literature it is found that Borate compounds find several interesting applications. In borate compounds boron atom is coordinated by oxygen atoms to form a variety of atomic groups that affect the physical properties in general and optical properties in particular. In the past decades, much research interest has been focused on the synthesis and characterization of inorganic borates for exploring nonlinear optical materials [1-5]. Several borate compounds find important application as TLD phosphors. However, they have not observed promising TL sensitivity in the phosphor so as to propose the same for TLD applications. Recently, a series of attempts have been made to investigate new borate materials as useful optical crystals in view of the demand for the nonlinear optical crystals in the deep UV band [6-9]. The demand for such material is increasing consistently because of the development of optical communications and the semiconductor large-scale integrated circuit. Synthesis of luminescent materials

specifically for borates by combustion method is found to be very useful and economically viable technique. Since this method provides uniform and narrow distribution of the particle size of the product, we have attempted combustion method for the synthesis of $LiMgBO_3$ [10-15].

Synthesis of $LiMgBO_3$ phosphors:

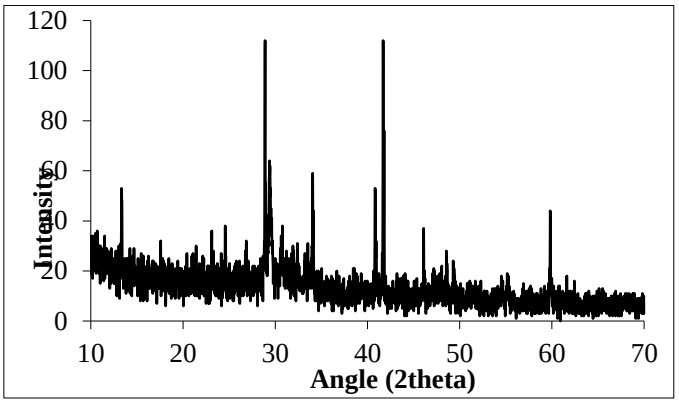
The stoichiometric amounts of high purity starting materials (Lithium Carbonate) Li_2CO_3, (Magneshium Nitrate) $Mg(NO_3)_2 \cdot 6H_2O$, (Boric Acid) H_3BO_3, (Urea) $CO(NH_2)_2$ and (Ammonium Nitrate) NH_4NO_3 were mixed thoroughly in agate mortar for about 30 minutes, so that the paste was formed. A stock solution of Dy_2O_3 and $MnCl_2 \cdot 4H_2O$ in stoichiometric amount was then mixed separately in paste. Above paste was put in the pre-heated furnace (550°C) after warming it for 5 minutes. (we have used the Laboratory made Muffle Furnace). The self-heat generating redox reaction was completed within 5 minutes and the fine powder of $LiMgBO_3$:Dy and $LiMgBO_3$:Mn was obtained. The obtained raw powders were sintered for 1.5 hour at 700^{0}C and quenched to room temperature on aluminum plate. The balanced chemical reactions for $LiMgBO_3$:Dy and $LiMgBO_3$:Mn phosphors are reported as below :

$$0.5Li_2CO_3 + Mg(NO_3)_2 \cdot 6H_2O + H_3BO_3 + 5(NH_2)_2CO + 4NH_4NO_3 + 0.0005Dy_2O_3\ (1000ppm) + 2.5O_2 \rightarrow LiMgBO_3:Dy + (5.5CO_2 + 4NH_3 + 4NO_2 + 19.5H_2O + 6N_2)\uparrow$$

$$0.5Li_2CO_3 + Mg(NO_3)_2 \cdot 6H_2O + H_3BO_3 + 5(NH_2)_2CO + 4NH_4NO_3 + 0.001\ MnCl_2 \cdot 4H_2O\ (1000ppm) + 2.5O_2 \rightarrow LiMgBO_3:Mn + (5.5CO_2 + 4NH_3 + 4NO_2 + 19.5H_2O + 6N_2)\uparrow$$

XRD of Synthesized Phosphor:

Figure 1 shows the XRD pattern of $LiMgBO_3$ Phosphor synthesized by combustion synthesis, it is exactly match with the standard available data.



TL Study of $LiMgBO_3$ Phosphor:

Figure 2 shows the typical glow curves for $LiMgBO_3$ doped with various impurities exposed to γ ray (exposure of 5 Joule/Kg). Curve (a), (b), (c), (d) & (e) are for Dy, Cu, Ce, Eu, & Mn respectively. The intensity for the activator Dy was found to be more than 10 times than the other activators. Therefore the glow curve of $LiMgBO_3$:Dy (curve a) is divided by 10 to fit in the scale. The main peak in this host for all activators is found around 165C. It is close to the TL peak of most of the TLD phosphors currently used. Since the peak is single and simple (symmetric) and further moderate value of its full width at half maximum, it could be used for the dosimetry studies provided. It satisfies the other requirements. In short, the activator Dy is found to be suitable dopant in $LiMgBO_3$ host [16-23].

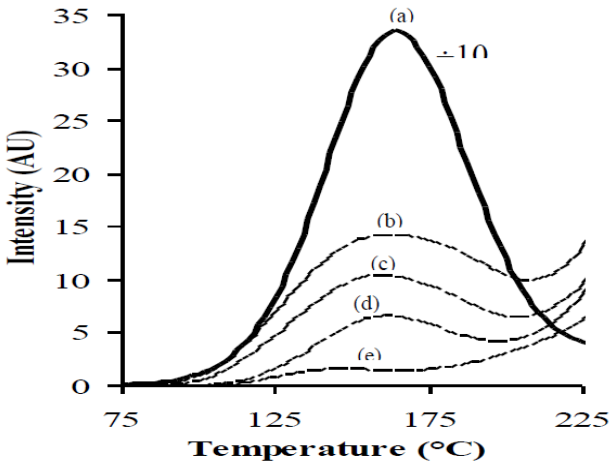


Fig.2 Typical glow curves for LiMgBO3 doped with various impurities exposed to 5 Joule/kg.

(a) Dy, (b) Cu, (c) Ce, (d) Eu (e) Mn. Curves (a) is divided by 10 to fit the ordinate scale.

II. CONCLUSION

1. The combustion synthesis is successfully employed for the preparation of the new potential phosphors namely $LiMgBO_3$ doped with the activators Cu, Ce, Eu, Dy & Mn.
2. The XRD profile of the phosphor is found to show good agreement with the literature.
3. This agreement has proved the combustion method is very useful for the synthesis of $LiMgBO_3$
4. Dy is most suitable dopant in $LiMgBO_3$ host out of all activators with regard to Thermoluminescence behavior.
5. $LiMgBO_3$:Dy seems to be promising TLD materials because of their low Z values, provided it is improved further for TL sensitivity.
6. $LiMgBO_3$:Dy is having 5% of the TL sensitivity as compared to $CaSO_4$:Dy (RchenTech, TT88) whereas it is about 22 % in case of $LiCaBO_3$:Dy when exposed to γ rays.
7. There is scope for improvement in the TL sensitivity of these materials.
8. These phosphors also found to respond β radiations equally as well.
9. The reusability is also been tested and it is found that even after 10 cycles of use, there is no much reduction (<15%) in the TL sensitivity.

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