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Optically Stimulated Luminescence (OSL) Properties of Limgpo4:Tb3+, Al Phosphor for Radiation Dosimetry

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ABSTRACT

The polycrystalline sample of LiMgPO4:Tb^{3+}, Al phosphor was successfully synthesized by using solid state method. The X-ray powder diffraction, photoluminescence (PL) emission & excitation spectra and optically stimulated luminescence (OSL) were thoroughly measured. The PL spectra of as-prepared LiMgPO4:Tb^{3+}, Al phosphor showed characteristic blue-green emission, when excited by 224 nm under UV excitation. The LiMgPO4:Tb^{3+}, Al phosphor shows good OSL sensitivity, which was found to be more than α-Al2O3:C and LiMgPO4:Tb^{3+}, B phosphor. The effective atomic number of LiMgPO4:Tb^{3+}, Al phosphor (Zeff = 11.44) is nearly similar to Zeff of α-Al2O3:C phosphor (Zeff = 11.28).

Keyword: Radiation dosimetry; OSL; PL; Phosphate; LiMgPO4:Tb^{3+}, Al

I. INTRODUCTION

Radiation dosimetry using luminescence techniques has made tremendous progress during the last three decade. Some techniques (TL, OSL and passive solid state detectors) have now found routine use and have received due recognition. Among them, optically stimulated luminescence dosimetry (OSLD) is one of the techniques used in radiation dosimetry. OSL has virtually replaced thermoluminescence (TL) dosimetry. The OSL technique is a now well developed and extensively used in radiation dosimetry application [1]. Antonov- Romanovskii et al firstly suggested application of OSL for personal dosimetry [2]. This technique got momentum for personnel dosimetry after the development of α-Al2O3:C and properties of α-Al2O3:C has been investigated for personnel dosimetry, environmental dosimetry, medical dosimetry and space dosimetry. OSL technique is more popular in radiation dosimetry because of its advantages [3].

The LiMgPO4 host is a typical example in phosphate based ABPO4 compounds [4]. Recently, LiMgPO4:Tb3+, B has become a material of choice for OSL dosimetry, because it has excellent dosimetric properties such as high sensitivity, reusability, stability and effective atomic number (Zeff=11.44) as compared to commercial available material α-Al2O3:C (Zeff=11.28) [5]. The OSL/TL properties LiMgPO4:Tb3+, B phosphor was first time reported by Dhabekar et al. in 2011 [1]. Kumar et. al. have focused over the theoretical and experimental studies on OSL properties of LiMgPO4:Tb3+, B [6]. Gai et al. reported Sm doped LiMgPO4:Tb3+, B phosphor for real-time dosimeter based on the OSL technology for personal monitoring as well as for food irradiation. Bajaj et. al. reported role of boron in LiMgPO4:Tb phosphor [7].

Form review it is confirmed that earlier workers developed this LiMgPO4 phosphor for various applications. There were no reports found on OSL properties of LiMgPO4:Tb3+, Al phosphor for radiation dosimetry.

In the present report we developed LiMgPO4:Tb3+, Al phosphor via modified solid state reaction for radiation dosimetry application.

II. EXPERIMENTAL DETAILS

The preparations of the LiMgPO4:Tb3+, Al was carried out by modified solid state reactions [8]. The structural confirmation of as prepared material was done by XRD analysis using Rigaku miniflex II X-ray diffractometer. The TL/OSL measurement was carried out using an automatic Risø TL/OSL-DA-20 reader system at RPAD divison BARC (Mumbai). Irradiations of all the samples were performed at room temperature using a calibrated 90Sr/90Y β source in-housed in RISO TL/OSL Reader (DA-20 Model). PL and PL excitation (PLE) spectra were measured on (Hitachi F-7000) fluorescence spectrophotometer with a 450W xenon lamp, in the range 200–700 nm, with spectral slit width of 1 nm and PMT voltage 700V at room temperature.

III. RESULTS AND DISCUSSION

Structural confirmation

The crystal phase formation of the sample was checked by using powder X-ray diffraction technique. The XRD pattern of LiMgPO4:Tb3+, Al as shown in Fig. 1. The experimental pattern of LiMgPO4: Tb3+, Al phosphor was compared with the ICDD (International Centre for Diffraction Data) pattern having PDF card No- 00-032 0574. By comparison between them the positions and intensity of the main peaks are same. No impurity lines were observed, indicating the only crystalline nature of sample. The crystallographic data are given in Table 1.

Table 1: Crystallographic data of Li2MgPO4:Tb3+, Al phosphor

Chemical Formula	LiMgPO4:Tb3+, Al
Crystal Structure	Orthorhombic
Space Group	Pmnb (62)
a (Å)	5.906
b (Å)	10.139
c (Å)	4.690
α (°)	90.000
β (°)	90.000
γ (°)	90.000
V (Å3)	280.84
Z	4

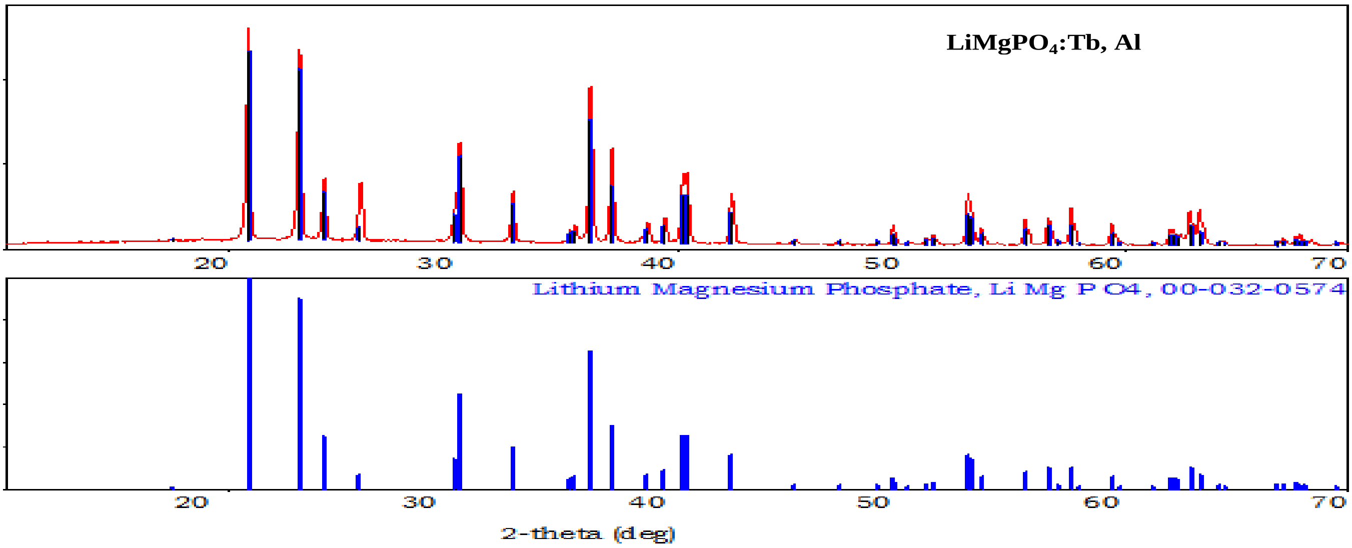

Fig. 1: X-ray diffraction pattern of LiMgPO4:Tb3+, Al phosphor with standard ICDD File.

Photoluminescence (PL) properties

Excitation and emission spectra of LiMgPO4:Tb3+, Al phosphor are as shown in Fig. 2. The excitation was measure at 544 nm and emission was measure at 224 nm.

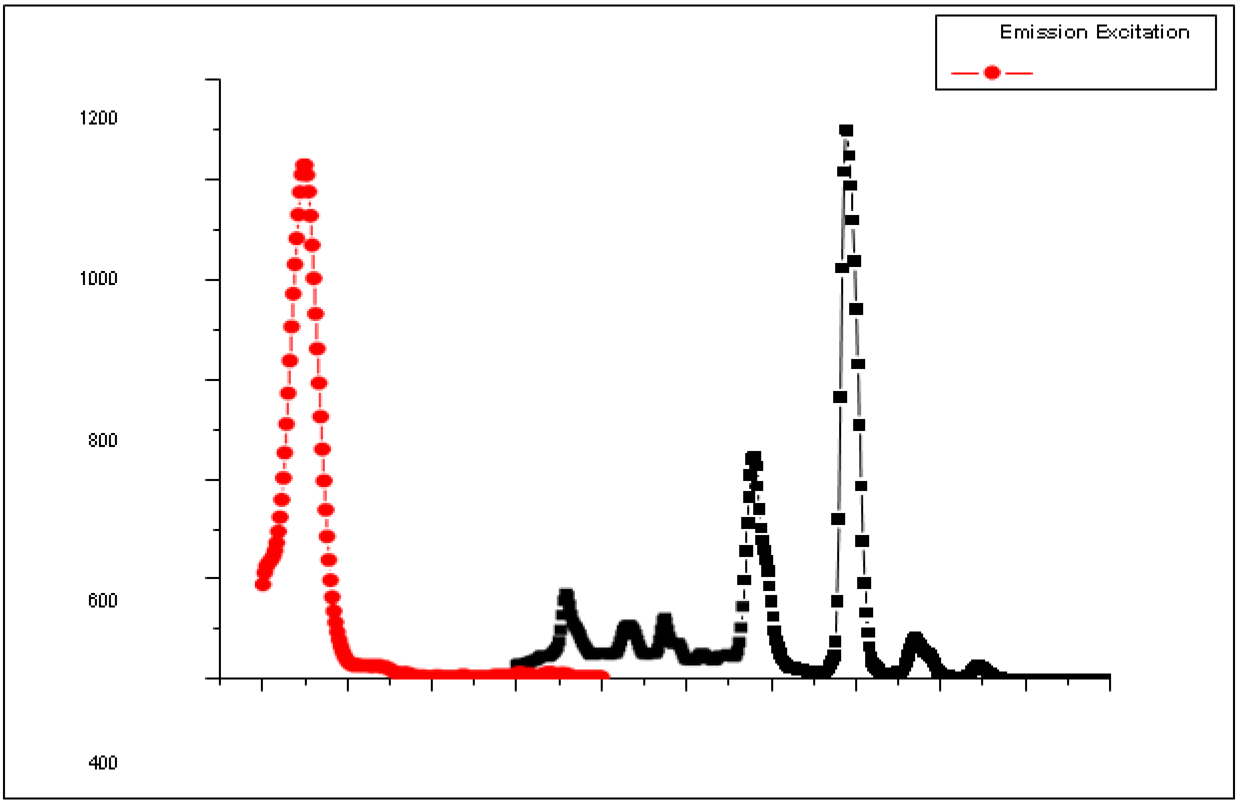

Fig. 2 Excitation and emission spectra for LiMg(1-0.015)PO4:0.01Tb3+,0.005Al.

The excitation spectra consist of broad band around 224 nm, corresponds to 4f–5d transitions of Tb3+ The emission spectrum consists of a series of sharp line speaking at 380, 418, 439, 490, 544, 583 and 621 nm corresponding to transitions 5D3 – 7F6, 5D3 – 7F5, 5D3 – 7F4, 5D4 – 7F6, 5D4 – 7F5, 5D4 – 7F4, 5D4 – 7F5 and 5D4 –7F6 respectively [9].

OSL Characterization

CW-OSL Studies

The sample was studied for its OSL response using blue LED stimulation (470 nm). For getting background OSL singles obtained for un-irradiated sample was subtracted from the OSL signals obtained for irradiated sample.

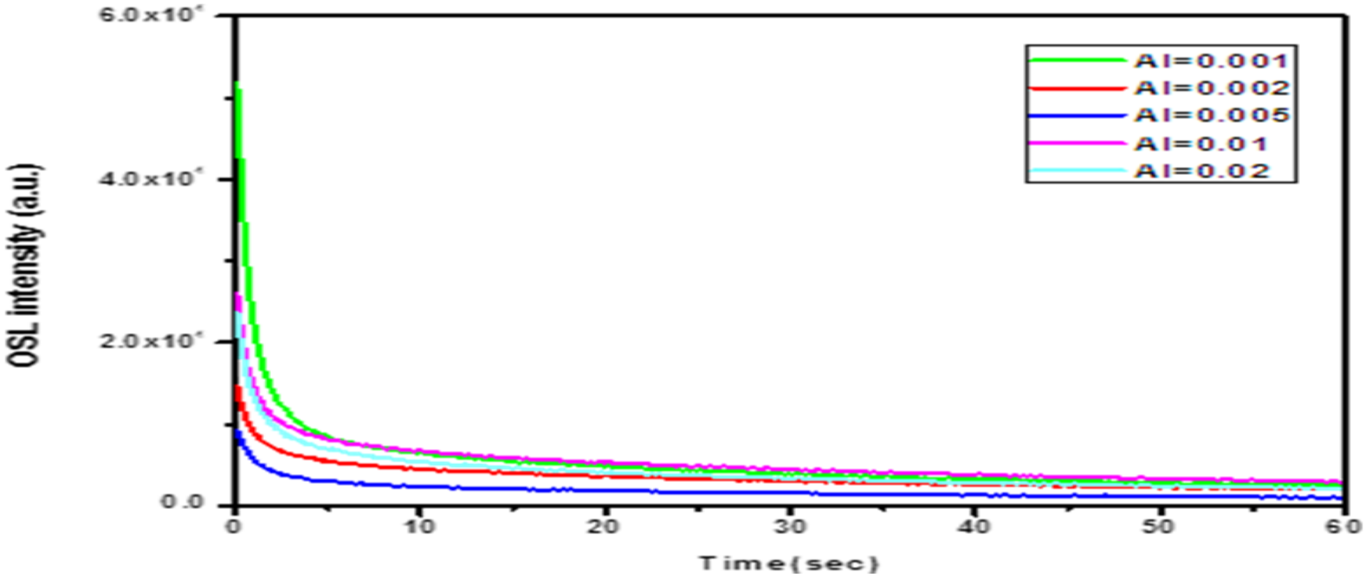

Fig. 3 OSL response of LiMgPO4:0.01Tb3+, yAl (y = 0.001, 0.002, 0.05, 0.01, 0.02) phosphor under β irradiation

Fig. 3 shows the OSL response of LiMg(1-0.01-y) PO4:0.01Tb3+, yAl (y = 0.001, 0.002, 0.005, 0.01 and 0.02) phosphor under 20 mGy of β irradiation. Also form same figure observed that OSL intensity was optimum at Al = 0.001 mol. The OSL sensitivity of LiMgPO4:Tb3+, Al phosphor was compared with the α-Al2O3:C and LiMgPO4:Tb3+, B phosphor as shown in Fig. 4. OSL sensitivity of LiMgPO4:Tb3+, Al phosphor was more than α -Al2O3:C and LiMgPO4:Tb3+, B phosphor.

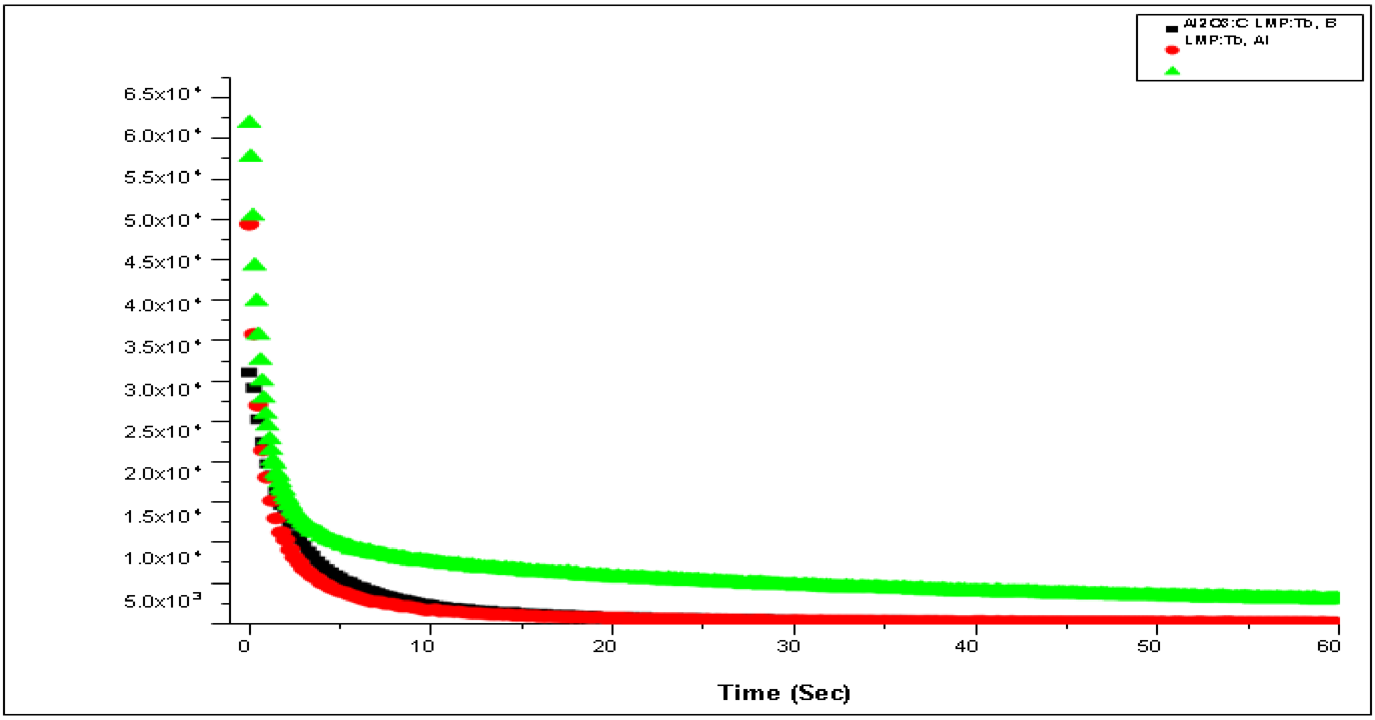

Fig.4: OSL sensitivity of LiMgPO4:Tb3+, Al phosphor compared with α-Al2O3:C and LiMgPO4:Tb3+, B Phosphors

IV. CONCLUSIONS

The polycrystalline sample of LiMgPO4:Tb3+, Al phosphor was successfully synthesized by using solid state method. The XRD pattern of LiMgPO4:Tb3+, Al phosphor was in good agreement with the ICDD file with card No. 00-032 0574. The PL emission spectra show characteristic blue-green emission under UV excitation. In OSL mode LiMgPO4:Tb3+, Al phosphor show good OSL sensitivity more than that of α-Al2O3:C and LiMgPO4:Tb3+, B phosphors . The Zeff of LiMgPO4:Tb3+, Al phosphor is nearly equal to Zeff of α-Al2O3:C phosphor. This LiMgPO4:Tb3+, Al phosphor can be proposed as a suitable candidate for radiation dosimetry applications.

V. ACKNOWLEDGEMENT

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