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Thermoluminescence and Optically Stimulated Luminescence Properties of MgB_4O_7: Ag Phosphor

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Abstract- Polycrystalline sample of MgB_4O_7:Ag phosphor was synthesized via solid state reaction and investigated for its thermoluminescence (TL) and optically stimulated luminescence (OSL) properties. The structure of prepared phosphor was confirmed by X-ray diffraction pattern that matched with JCPDS file. TL glow curve consisted of overlapping peaks in temperature range 323 to 573°K and kinetics parameters such as activation energy, frequency factor and order of kinetics were calculated. CW-OSL curve of prepared phosphor consist three components (fast, medium and slow).

Keywords: Solid state reaction, X-ray diffraction, kinetics parameters, dosimetry
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1.0 Introduction

Borate base phosphors ($Li_2B_4O_7$, MgB_4O_7 and SrB_4O_7 etc.) are host matrices of interest for luminescence applications, including thermoluminescence (TL) and optically stimulated luminescence (OSL) dosimetry of ionizing radiation [1-3]. These materials are attractive in dosimetry due to their low effective atomic number. Rawat *et al.* (2012) proposed lithium borate doped with Ag crystal as a dosimeter for radiation dosimetry applications because of its tissue equivalence [4]. Annalakshmi *et al.* reported magnesium tetraborate doped with rare earth elements (RE) phosphor for medical dosimetry applications [5]. Also many researchers developed borated based phosphor for TLD/OSLD applications [6, 7]. MgB_4O_7: RE phosphor is attractive in dosimetry because for its low Z_{eff} = 8.4, small photon energy dependence. Its TL peaks occurred in temperature range 450°C to 570°K. This phosphor is used for neutron dosimeters and temperatures sensing applications. [8, 9].

To our knowledge, RE-doped MgB_4O_7 phosphor synthesized via solid state method and its OSL properties under beta irradiation has not been reported. In present work, we report the TL/OSL of MgB_4O_7:Ag phosphor prepared via solid state method.

2. Experimental

MgB_4O_7 phosphor doped with Ag was synthesized by using solid state method. High purity starting materials Magnesium nitrate (Mg $(NO_3)_2.6H_2O$), Boric acid (H_3BO_3) and Silver nitrate ($AgNO_3$) were used for synthesis. The stoichiometric mixture was mixed and small amount of acetone was added. This mixture was heated in mufal furnace at 800 °C for 5 hr. Then sample was suddenly quenched to room temperature and ground in agate morter. The phase purity of MgB_4O_7:Ag sample was checked by powder X-ray diffraction (PXRD) using a Rigaku miniflex II diffractometer. All TL/OSL measurements were carried out using an automatic Risø TL/OSL-DA-15 reader system at BARC Mumbai.

3. Result and Discussion

3.1 XRD-Studies

Formation of the compound was confirmed by using XRD pattern. Fig. 1 shows the X-ray diffraction pattern of synthesized MgB_4O_7: Ag phosphor. The XRD pattern of prepared phosphor matched with the Joint Committee on Powder Diffraction Standards (JCPDS) data and JCPDS card No. 31-0787. The X-ray diffraction pattern shows that the crystal structure was orthorhombic with a space group Pbca and lattice parameters a = 13.475 Å, b = 8.200 Å, c = 7.952 Å. [5].

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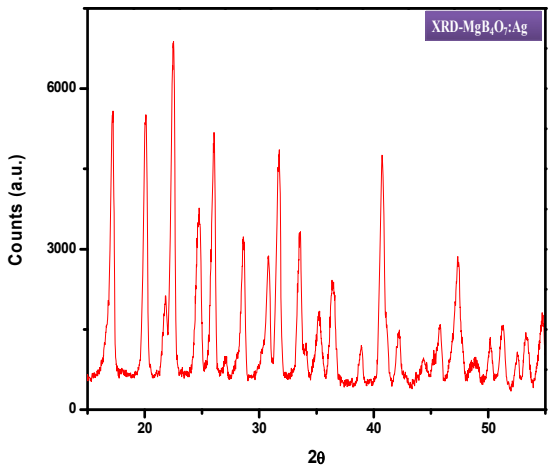

Fig. 1 X-Ray diffraction pattern of MgB_4O_7:Ag phosphor

3.2 Thermoluminescence (TL)

Fig. 2(A) represents the thermoluminescence glow curve of MgB_4O_7:Ag phosphor. During this study sample was exposed to 500mGy of β-ray radiation. TL glow curve of MgB_4O_7:Ag phosphor observed in temperature range 320 to570°C.

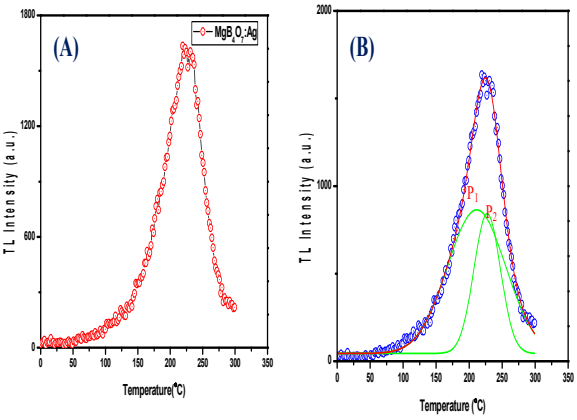

Fig. 2(A) TL response of MgB_4O_7:Ag phosphor under beta radiation and Fig. 3(B) Deconvolution of TL glow curve of MgB_4O_7:Ag phosphor

Figure 2(B) shows deconvoluted curve of MgB_4O_7:Ag phosphor. TL glow curve consists of overlapping peaks out of which one peak appeared at 483°K and another at 499°K. Kinetic parameters such as activation energy (E) and frequency factor (s) of the glow peak were calculated using convenient peak shape method [10, 11]. From geometrical factor (μg), it was confirmed that the glow peaks follow the second order kinetics. The calculated activation energy and frequency factor are given in Table 1.

Table 1 Kinetic parameter of MgB_4O_7:Ag phosphor

Phosphor	Peaks	Activation energy (eV)	Frequency factors (s^{-1})	Shape factors (μ_g)
MgB_4O_7: Ag	P_1	0.589	1.56×10^5	0.50
	P_2	1.465	1.66×10^{16}	0.53

3.3 Optically stimulated luminescence (OSL)

Fig. 3 represent CW-OSL response of MgB_4O_7:Ag phosphor under beta irradiation and this curve fitted with 3rd order exponential decay. Blue light stimulated decay curve consists of three components fast, medium and slow.

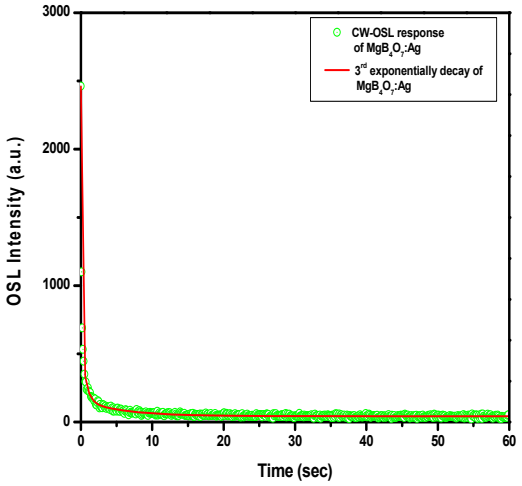

Fig. 3 CW-OSL response of MgB_4O_7:Ag under beta irradiation

4. Conclusions

Polycrystalline sample of MgB_4O_7: Ag phosphor was synthesized by the simple solid state route. The XRD pattern of MgB_4O_7: Ag was in good agreement with JCPDS data. The main TL glow curve appeared in temperature range 4200-570°K, which is favorable for the reduction of fading effect. The deconvoluted TL glow curve consisted two peaks and one peak appear at 483°K and the second at 499° K. The kinetics parameters were calculated using peak shape method. The CW-OSL decay curve of the phosphor consists of three components (fast, medium and slow). Z_{eff} of prepared phosphor is 8.4. MgB_4O_7: Ag phosphor was sensitive to TL and OSL mode and hence this phosphor may be proposed as a suitable candidate for radiation dosimetry, after further studies.

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