Mechanoluminescence Characterization of γ - irradiated $Ba_3 (VO_4)_2$: Eu phosphors

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Abstract: ***Present paper reports mechanoluminescence characteristic of $Ba_3 (VO_4)_2$: Eu phosphors. $Ba_3 (VO_4)_2$ samples having different concentration of Eu have been prepared by solid state diffusion technique. Formation of the samples was confirmed by taking XRD data. Gamma irradiation was carried out using ^{60}Co source. ML was excited impulsively by dropping a load on to the sample. $Ba_3 (VO_4)_2$: Eu (0.1 mole%) phosphors shows the maximum ML intensity. The dependence of ML intensity on γ - dose has also been studied. ML emission spectrum contains a broad peak around 606 nm. ML emission around 606 nm in the $Ba_3 (VO_4)_2$: Eu may be due to transition of Eu^{3+} ions.***

Keywords: Mechanoluminescence, XRD, solid state reaction

1. Introduction

The current research focus of lighting industry is the development of solid state lighting (SSL). SSL technology utilizes a combination of light emitting diode and phosphors to generate white light. The alkaline earth metal orthovanadates, $Me_3 (VO_4)_2$ (Me: Ca, Sr, Ba), have attracted much attention owing to their interesting optical, transport and ferroelectric properties [1 - 7]. The intensity of luminescence in $Sr_3 (VO_4)_2$ and $Ba_3 (VO_4)_2$ can be additionally enhanced through the formation of the $Ca_3 (VO_4)_2$ - $Sr_3 (VO_4)_2$ and $Ca_3 (VO_4)_2$ - $Ba_3 (VO_4)_2$ solid solution series [2]. Among them barium orthovanadates exhibit intense rare earth activated luminescence and can be used as luminophors and host materials for lasers [1]. Orthovanadate shows luminescent properties and could be used in television tubes, luminescent lamp coatings and solid state lasers [1 - 3]. Orthovanadates exhibit oxygen ionic conductivity due to the migration of electrons between V^{4+} and V^{5+} centers [8]. Also, intense luminescence can be obtained by tuning the composition in the solid solution series between the isostructural orthovanadates and orthophosphates [8 - 11]. The luminescence and transport properties are determined by point defects and impurity ions whose valance state is different from that ions in a host lattice (e. g. rare - earth elements). The different rare earth containing materials, like orthovanadates and orthophosphates, are useful to assess the extent to which rare - earth ion parameters can be varied and possibly enhanced in various hosts. Using vanadate as host material offers possible solution of these problems due to increased absorption cross sections in rare earth ions [8 - 10].

Only limited investigation has been made on the ML of vanadate phosphor. The present paper reports the ML of $Ba_3 (VO_4)_2$: Eu phosphors.

2. Experimental

For the preparation of Eu doped $Ba_3 (VO_4)_2$ phosphors required amount of $BaCO_3$, V_2O_5 and Eu_2O_3 were mixed thoroughly in stoichiometric ratio (3: 1 mole %). This was then transferred into a J - mark porcelain crucible and heated in muffle furnace by slowly raising the temperature to about 500^0C and kept this temperature for 4 hours and then cooled to room temperature. Again it was crushed and transferred to a furnace at 550^0C for 12 hours then cooled to room temperature. The resulting compound was again crushed and kept at 550^0C for 1 hour then quenched to room temperature. Formation of compound was confirmed by taking XRD of sample (Fig.1) and matched with standard data of JCPDs (file no.00 - 029 - 0211). Gamma irradiation was carried out using a ^{60}Co source. The ML was excited impulsively by dropping a load of 0.4kg onto the sample from the height of 5 cm and luminescence was monitored by PMT connected with the storage oscilloscope. A sample of 2.0 mg was used every time for recording the glow curves. The ML spectra were recorded using a series of optical band pass filter.

3. Results

Fig.2. shows that the time dependence of the ML intensity of Ba3 (VO4) 2: Eu samples for different concentration of Eu. Only one peak is observed. It is also observed that the ML intensity initially increases with increasing dopant concentration, attains an optimum value for a particular concentration of dopant (0.1 mol%) and then decreases with further increase in concentration of dopant.

Fig.3. shows that the the ML intensity of Ba $(VO_3)_2$: Eu (0.1 mol%) phosphors increases with increasing mass of load dropped on to the sample.

Fig.4. shows the dependence of total ML intensity of $Ba_3 (VO_4)_2$: Eu (0.1 mol%) samples on γ - dose given to the sample. Initially the ML intensity increases with increasing γ - doses and seems to saturate above $1.4x10^3$ Gy. The variation in ML intensity with γ - dose is not significant as observed for alkali halides and sulphate based phosphors.

Fig.5. shows the ML emission spectra of $Ba_3(VO_4)_2$: Eu (0.1 mol%) samples. A broad peak around 606 nm is observed which is probably due to Eu^{2+} ions.

4. Discussion

Mechanoluminescence is sensitive methods for studying radiation induced effects in the luminescent materials. Non - irradiated undoped and doped $Ba_3(VO_4)_2$ samples do not show ML. The occurrence of ML in this material and enhancement of ML with gamma irradiation show the involvement of radiation induced defect centers in ML excitation process. The presence of impurities enhances the probability of formation of defect centers especially if the impurity has a different valence state than the ion it replaces such as RE^{3+} replacing Ba^{2+}.

On the basis of experimental results it is suggested that when Eu doped $Ba_3(VO_4)_2$ is exposed to γ - rays the Eu^{3+} acting as electron trap gets reduced to Eu^{2+} with the production of trapped hole center (VO_4^{2-}) elsewhere. The holes are released on mechanical excitation. Recombination with electron at Eu^{2+} site leads to the formation of Eu^{3+} in electronically excited state. Luminescence is observed during de - excitation of the excited Eu^{3+} ion. Weak ML of $Ba(VO_3)_2$: Eu shows that the probability of formation of trapped hole center is very less in this system.

5. Conclusion

Non irradiated undoped and Eu doped barium orthovanadates do not show ML. Although the ML increases with gamma dose but the variation in ML is small as compared with other ML materials.

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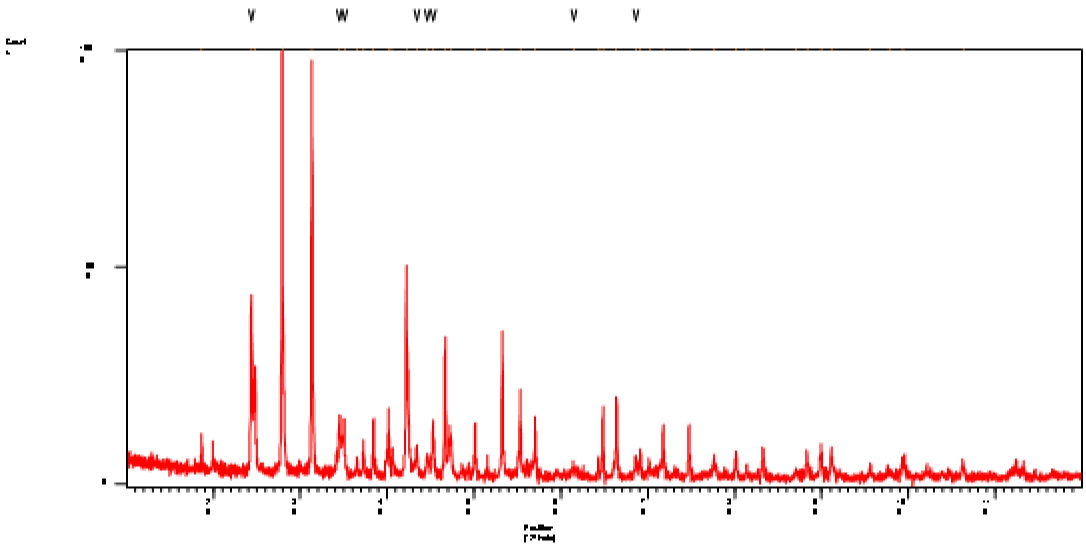

Figure 1: XRD pattern of $Ba_3(VO_4)_2$ phosphors

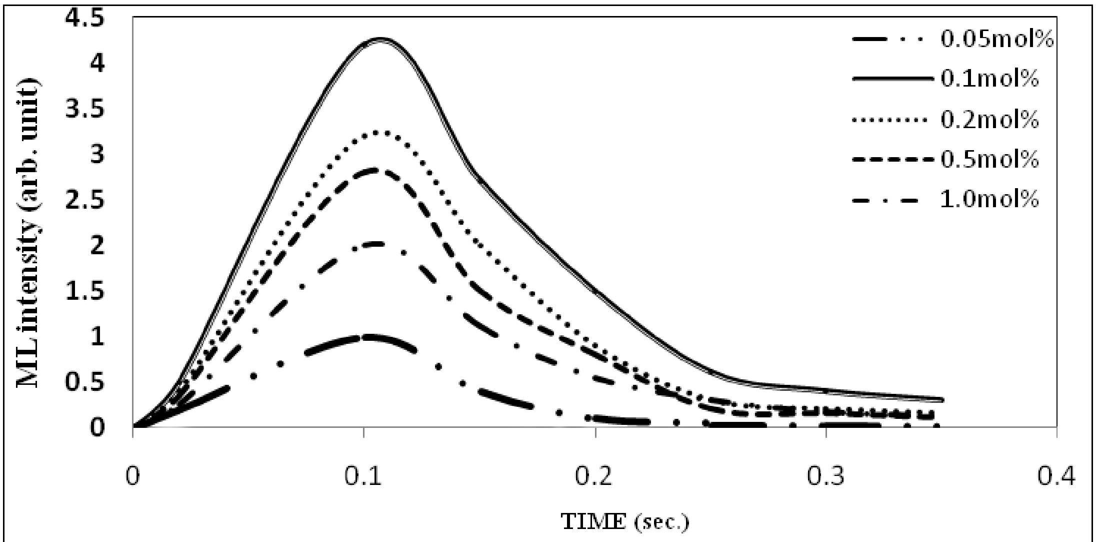

Fig .2. TIME DEPENDENCE OF THE ML INTENSITY OF γ-IRRADIATED $Ba_3(VO_4)_2$: Eu (0.1 mole %) QUENCHED SAMPLES FOR DIFFERENT CONCENTRATION

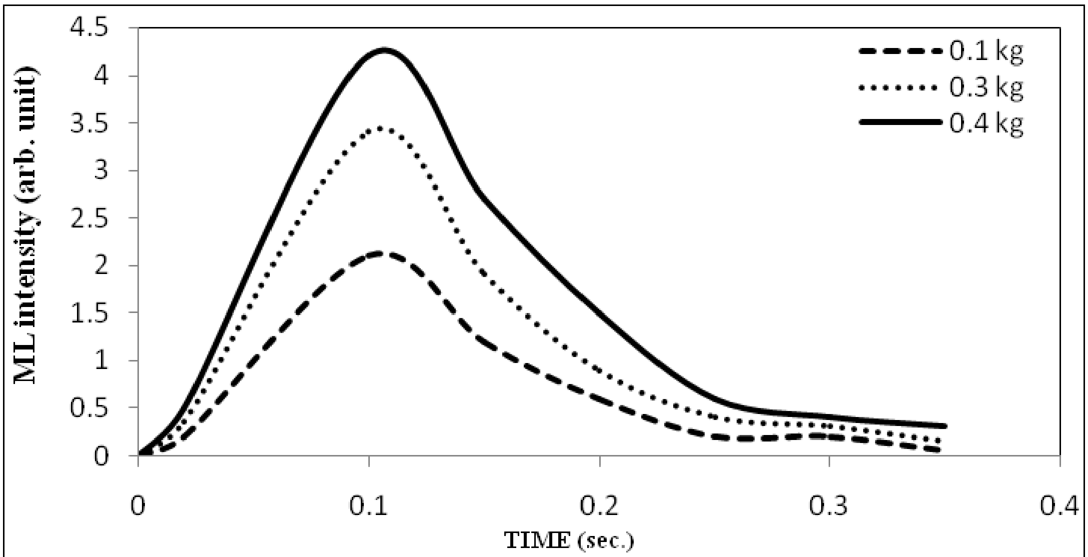

Fig .3. TIME DEPENDENCE OF THE ML INTENSITY OF γ-IRRADIATED $Ba_3(VO_4)_2$: Eu (0.1 mole %) FOR DIFFERENT MASS OF PISTONS

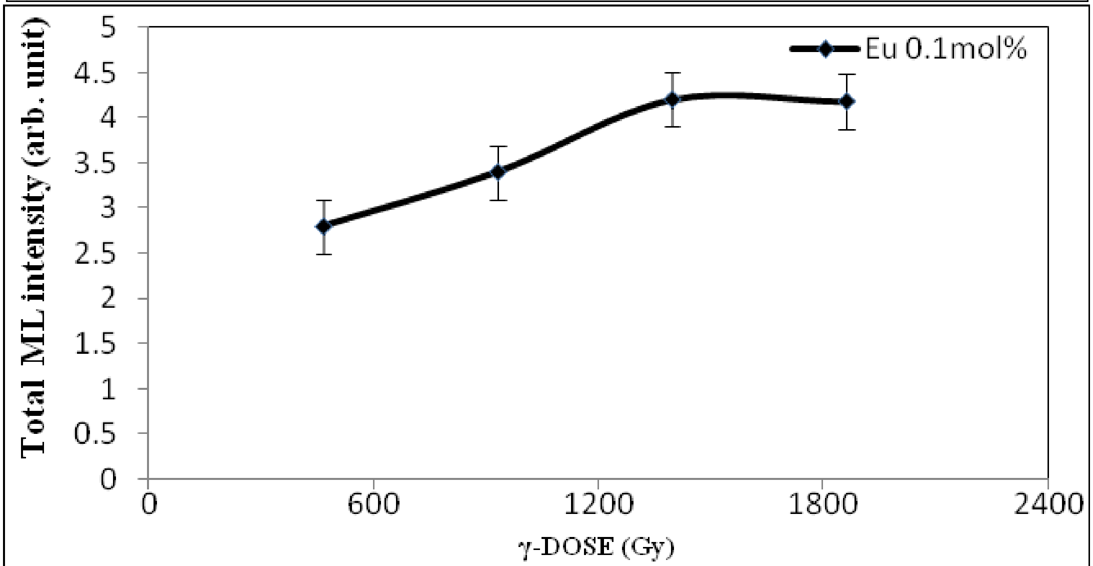

Fig.4. γ- dose DEPENDENCE OF TOTAL ML INTENSITY OF $Ba_3(VO_4)_2$: Eu (0.1 mole%) SAMPLES

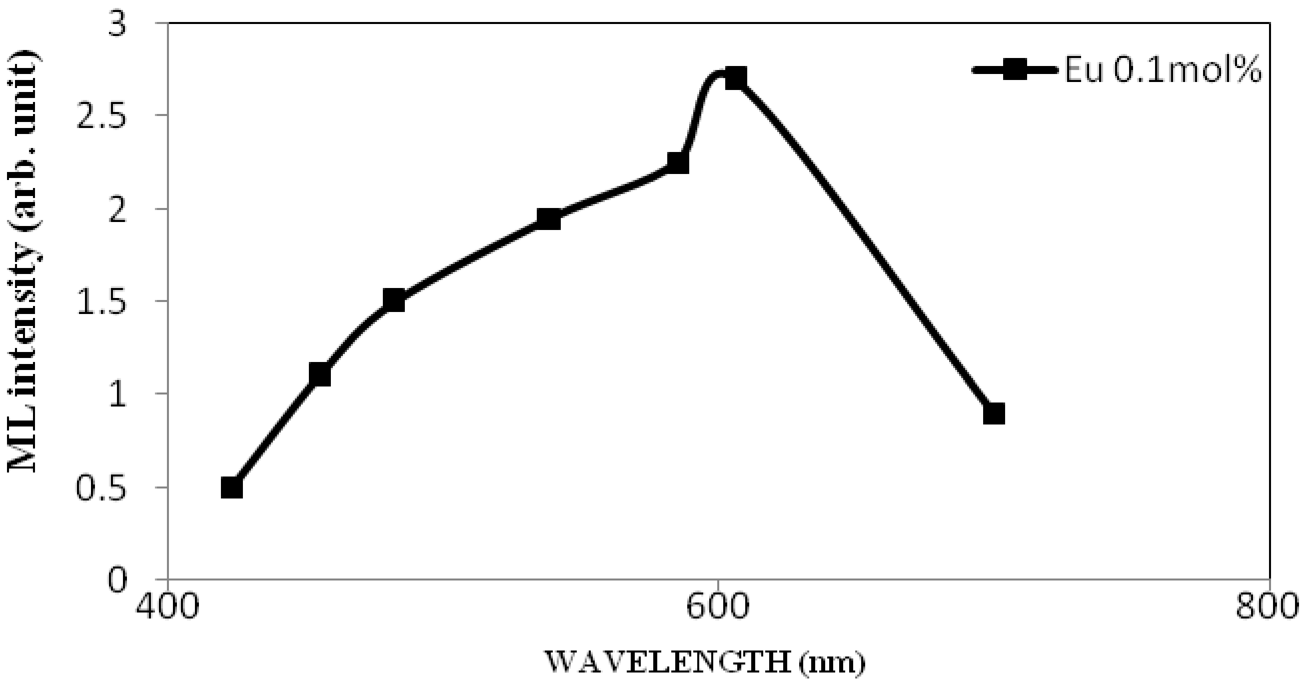

Fig. 5. ML EMISSION SPECTRA OF γ-IRRADIATED $Ba_3(VO_4)_2$: Eu (0.1 mole%) SAMPLES

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