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Comparative study on mechanoluminescence of Eu^{2+} doped phosphate based phosphors.

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Abstract

Eu^{2+} doped phosphate based phosphors were prepared by solid state diffusion technique. The phosphors have simple glow curve with single peak It is clear that the ML intensity increases with increasing concentration of Eu, attained an optimum value for 1 mole % for $Sr_5(PO_4)_3Cl:Eu^{2+}$, and 2 mole% for $Li_3PO_4:Eu^{2+}$ and $LaPO_4:Eu^{2+}$, then decreases with further increase in concentration of Eu. The trapping and detrapping of charge carriers in the material can be studied using ML. It is believed that in the dynamic process of loading, internal friction originating from defects activates holes released from traps and stimulates mechanoluminescience. This phosphor can be used in the dosimetry of ionizing radiations using mechanoluminescence.

Keywords: Mechanoluminescence, phosphors, ionizing radiations

INTRODUCTION

Mechanoluminescence(ML) is a type of luminescence induced during or following any mechanical action on solids. It can be excited either by grinding, rubbing, cutting, cleaving, shaking, scratching, compressing or by impulsive crushing of solids. Mechanoluminescence(ML) is used to describe the whole variety of processes in which light is emitted due to application of mechanical energy on solids. At present this effect is used widely in investigation of deformation and fracture of solids. This technique offers a number of interesting possibilities such as detection of cracks in solids and for mechanical activation of various traps present in the solids.

Chandra et al (2010) reported when a load is applied on to a crystal, then the fracto- mechanoluminescence (ML) emission takes place in the form of light pulses.

Rare earth doped polycrystalline $Ca_3(PO_4)_2$:Eu, $Ca_3(PO_4)_2$:Dy and $Ca_3(PO_4)_2$:Eu,Dy phosphors prepared by a modified solid state synthesis have been studied for its thermoluminescence(TL) and Photoluminescence(PL) characteristics by I.M.Nagpure et al.2009. Chandra et al (2010) reported when a load is applied on to a crystal, then the fracto- mechanoluminescence (ML) emission takes place in the form of light pulses.Synthesis and mechanoluminesce characterization of $LaPO_4$:Eu was studied by A.K.Sahu et al.2011. $Sr_5(PO_4)_3Cl$: Dy phosphor prepared by solid state diffusion technique and its mechnoluminescence characteristics is studied by A.K.Sahu et al.2012.

Bhujbal et al (2012) reported the mechanoluminescence (ML) of γ-irradiated coloured powder of (KNa)Br:Ce(0.1–10 mol%) phosphor In this present paper we compare the mechanoluminescence characterization of Eu^{2+} doped some different phosphate based phosphor for dosimetry of ionizing of radiation.

EXPERIMENTAL DETAILS

Eu^{2+} doped phosphate based phosphors were prepared by solid state diffusion technique The experimental setup used for impulsive excitation of ML in γ- irradiated impurity doped phosphate phosphors is as follows; The sample was placed on the upper surface of a transparent Lucite plate. It will be covered with a thin aluminum foil and fixed with adhesive tape. The load of different masses was dropped from different heights and the impact velocity of the load was changed. For taking ML measurement the phosphor was placed on a transparent Lucite plate, inside a sampler holder below the guiding cylinder and the luminescence was monitored below the transparent plate using an RCA 931A photomultiplier tube connected to a storage oscilloscope (SCINTIFIC HM-205). The photomultiplier housing is made of thick soft iron to provide a shielding from light and magnetic field. The slit arrangement at the window is provided to adjust the size of the window according to the incident beam.

The ML intensity was monitored by the photomultiplier tube whose output will be fed to one channel of storage oscilloscope. For determining the peak intensity, peak position, rise and decay time of ML, trace on the oscilloscope screen was recorded on tracing paper.

RESULTS AND DISCUSSION

The phosphor has a single glow curve with a single mechanoluminescence peak.

Fig.1(a,b and c)shows the time dependence of ML intensity of some different phosphate based phosphor for the different concentrations of Eu. It is clear that the ML intensity increases with increasing concentration of Eu, attained an optimum value for 1 mole % for $Sr_5(PO_4)_3Cl:Eu^{2+}$, and 2 mole% for $Li_3PO_4:Eu^{2+}$ and $LaPO_4:Eu^{2+}$, than decreases with further increase in concentration of Eu.

Fig.2shows the time dependence of ML intensity of some different phosphate based phosphor for an optimum value of concentration of Eu.

Fig.3 shows the ML glow curves of some different phosphate based phosphor for different impact velocities of the piston. It is seen that the ML intensity increases with increasing impact velocity. However, the time corresponding to the ML peak(t_m) shifts towards shorter time values with increasing impact velocity.

Fig.4 shows the plot between log I and ($t-t_m$), for impulsive deformation. In fact the decay time of surface charges depends on CR, where C is the capacity and R is the resistance of sample. As the rate of detrapping of electrons directly related to the rate of change of the piezoelectric field, in the case of impulsive deformation C and R may decrease significantly hence the decay time is less in the impulsive deformation.

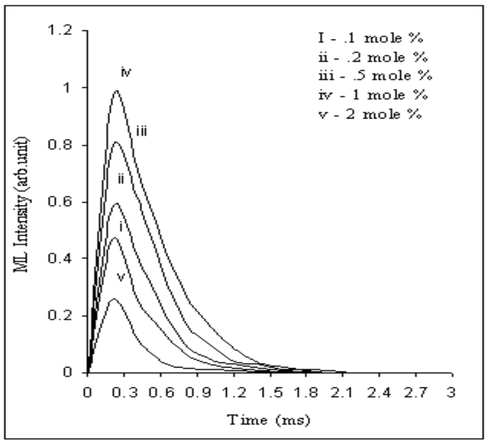

Fig1(a).Time dependance of the ML intensity of γ -irradiated $Sr_5(PO_4)_3Cl:Eu^{2+}$ sample for different concentration of Eu.

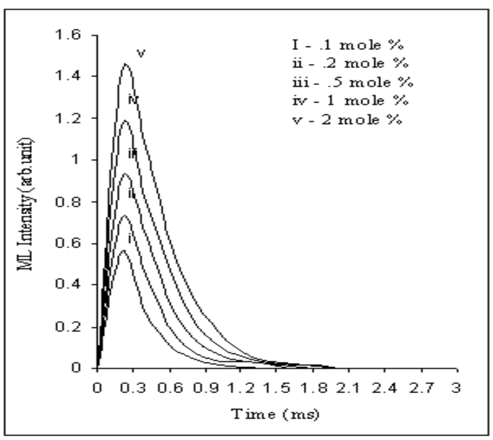

Fig.1(b). Time dependance of the ML intensity of γ -irradiated $Li_3PO_4:Eu^{2+}$ sample for different concentration of Eu.

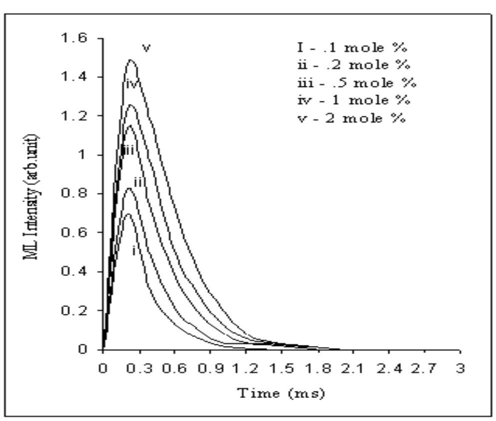

Fig.1(c). Time dependance of the ML intensity of γ -irradiated $LaPO_4:Eu^{2+}$sample for different concentration of Eu.

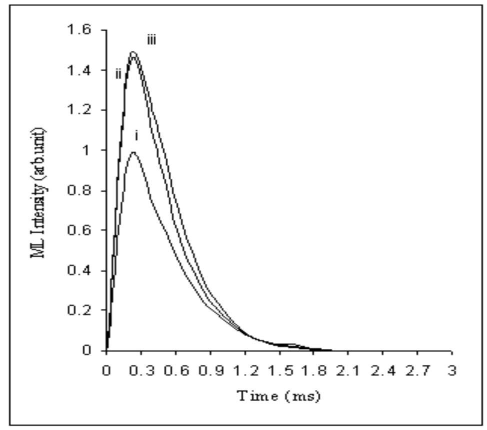

Fig 2. Time dependance of the ML intensity of γ -irradiated some different phosphate based phosphor.[i – $Sr_5(PO_4)_3Cl:Eu^{2+}$(1 mole%), ii – $Li_3PO_4:Eu^{2+}$(2 mole%), iii – $LaPO_4:Eu^{2+}$(2 mole%)].

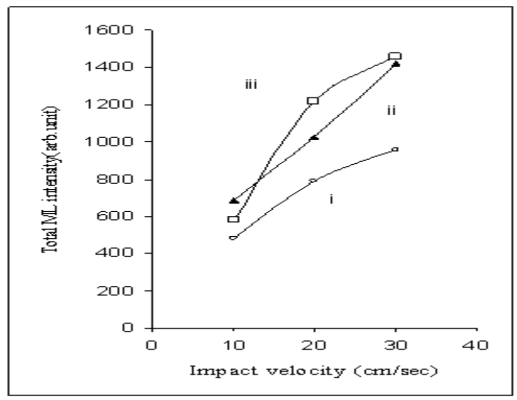

Fig 3. Dependance of the total ML intensity of γ- irradiated Eu^{2+} activated some different phosphate based phosphor on the impact velocity of the piston. [i – $Sr_5(PO_4)_3Cl:Eu^{2+}$, ii – $Li_3PO_4:Eu^{2+}$, iii – $Li_3PO_4:Eu^{2+}$].

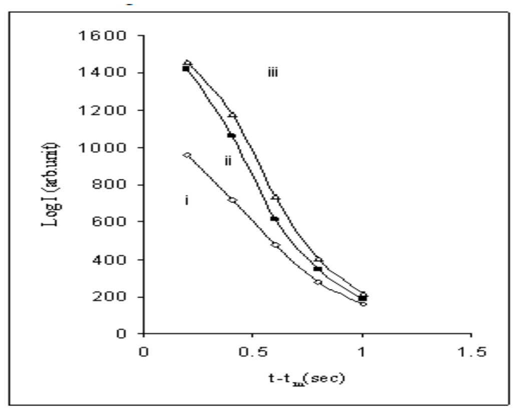

Fig 4. Plot of log I versus (t-tm) for some different phosphor for ML induced by droping a load from a hieght of 300 mm. [i – $Sr_5(PO_4)_3Cl:Eu^{2+}$, ii – $Li_3PO_4:Eu^{2+}$, iii – $Li_3PO_4:Eu^{2+}$].

CONCLUSION

Eu^{2+} doped some phosphate based phosphor has been prepared easily by solid state diffusion technique. It has simple glow curve with single peak It is clear that the ML intensity increases with increasing concentration of Eu, attained an optimum value for 1 mole % for $Sr_5(PO_4)_3Cl:Eu^{2+}$, and 2 mole% for $Li_3PO_4:Eu^{2+}$ and $LaPO_4:Eu^{2+}$, than decreases with further increase in concentration of Eu. The trapping and detrapping of charge carriers in the material can be studied using ML. It is believed that in the dynamic process of loading, internal friction originating from defects activates holes released from traps and stimulates mechanoluminescience. This phosphor can be used in the dosimetry of ionizing radiation using mechanoluminescence.

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