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Research Article

Synthesis And Mechanoluminescence Characterisation of Phosphor Baal2o4: Eu, Ce.

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Abstract

The mechanoluminescence (ML) of $BaAl_2O_4$: Eu, Ce phosphor was investigated. It was found that ML could be only produced by dynamic load. When a load is applied on to a crystal, then the mechanoluminescence (ML) emission takes place in the form of light pulse. The number of ML pulses and the time duration t_c for the appearance of ML increase with increasing value of the load and the average ML intensity from a single pulse decreases with increasing value of load For a given value of the applied pressure, the total number N_T of ML pulses, the total ML intensity I_T increases with increasing mass of the load. As the total ML intensity is directly related to the area of newly created surfaces increases with increasing value of the applied load and later on it tends to attain a saturation value for higher values of applied load. Static load, in the experimental limit, does not affect the decay process of the afterglow of the phosphor. In addition, ML can be induced by both loading and unloading process. Higher sensitivity of ML was observed at longer delay time when the load is applied after shut off the γ irradiation. Based on the results obtained, the source of ML is discussed.

Keyword-Mechanoluminescence, Experimental limit, Sensitivity

INTRODUCTION

Present trend in researches in science, leading to their fruitful use in practical situations, has acquired special significance. Applied researches particularly relevant to energy conservation and energy conversion problem have led to new discoveries and inventions in many fields. One of the attractive fields of research in this sense is the field of luminescence where, different forms of energy can be converted into optical energy. Luminescence is the process of emission of electromagnetic radiation from substances which is not purely thermal in origin. The sensitivity of luminescent material (phosphor) is strongly influenced by structural changes, chemical composition of the base compound, physical condition of preparation and the presence of the activator. An efficient phosphor is that which converts a large portion of the absorbed excitation energy into light with inappreciable energy losses by increase in lattice vibration or electron emission or chemical or structural changes.

The main principle of preparing phosphors is the incorporation of any impurity or defect in a pure lattice. For any composition of the initial charge, the impurities can be introduced in many ways and they can manifest themselves differently in luminescence depending on ambient medium, heating temperature, cooling rate, presence of defect associated with deviation from stoichiometry, etc. In recent years, such materials have become much interesting which have high luminescence efficiency and whose luminescence is due to the presence of small concentration of specific impurity. In such cases, the treatment usually creates a stoichiometric excess of ions or atoms probably occupying interstitial position in the crystal lattice. The material may be thought of impurity activated, since their luminescence characteristics are more akin to those of pure solids.

The effects of ionizing radiation in qualitative and quantitative terms has become very important in the present day context due to the influence of nuclear technology in various areas that include radiation medicine, radiotherapy, food processing, radiation based polymerization and nondestructive testing techniques using radiography. Dependable radiation dosimetry procedures need to be developed over wide range of dose levels.

Rare earth doped strontium illuminate phosphors have been found useful in the real time visualization of stress distribution in solids[1-2].The ML of $SrAl_2O_4$:Eu,Dy phosphors has been found to be suitable for the real time visualization of quasidynamic crack-propagation in solids. Jia et.al [3]. B.P.Chandra has reported the elastics ML induced by the applications of loads on colored alkali halide crystals [4]. Aman and tomes have shown that the factor ML can be used for online monitoring of grinding in milling machine [5]. . Synthesis and mechanoluminesce characterization of $LaPO_4$: Eu was studied by A.K.Sahu et al. [6]. $Sr_5(PO_4)_3Cl$: Dy phosphor prepared by solid state diffusion technique and its mechnoluminescence characteristics is studied by A.K.Sahu et al. [7]. A survey of the literature reveals that practical size studies have been mainly restricted to organic compounds. An alternative mode of light emission at room temperature is to release the stored energy in the irradiated material by dissolving it in an appropriate solvent. This phenomenon has attracted many researchers from various disciplines such as radiation physics, radiation chemistry and physical chemistry [8,9]. Synthesis and thermo luminescence properties of SrAl2O4 (EU) phosphor irradiated with cobalt-60, 6 MV and 16 MV photon beams [10]. Ag nanoparticles coated $CaTiO_3$: Eu phosphor obtained from charge attracting process shows higher PL intensity and enhanced heat dissipation than the uncoated ones due to the LSPR effect and heat conduction of Ag nanoparticles reported by Zhen Hua et al [11]. Rare earth Ce doped in $BaAl_2O_4$: Eu phosphors have high potential due to their excellent optical and dosimetric properties.

EXPERIMENTAL

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.

RESULT AND DISCUSSION

$BaAl_2O_4$: Eu Ce is a long persistent phosphor. Under γ irradiation, the Ce^{2+} ions are pumped to their excited state. Part of excited ions return to the ground state and emit a broad band light peak, and part of ions fall in traps and store their photo energy in the trapping state. The ions can leave the trapping state due to thermal activation, and emit as afterglow after turning off the γ irradiation. The typical decay curve of the afterglow of the samples $BaAl_2O_4$: Eu, Ce is very no exponential. The no exponential decay originates from different traps with different energy depths in the band gap of the host. Ions from shallow traps release their energy much faster and make major contribution to afterglow at early decay time.

The afterglow intensity immediately increased when the impact load is suddenly dropped into the sample. Fig. 1 shows a sudden increase of afterglow in the decay curve at the moment when a impulsive load is applied. In other word, ML can be stimulated only by dynamic load, but not static load.

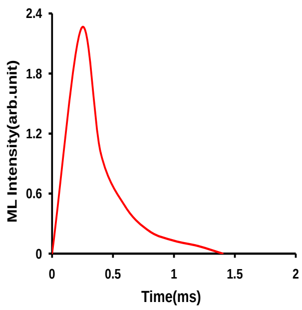

FIGURE 1

Fig.2 shows the ML intensity of the gamma irradiated rare earth doped phosphate-based phosphors depends upon the impurity concentration. ML intensity first increases with concentration of dopant, attains maximum value for a particular concentration then decrease with further increase in dopant concentration. For Ce, doped $BaAl_2O_4$:Eu phosphor the maximum ML intensity is observed at 0.5 mol% concentration of impurity. maximum value for a particular concentration then decrease with further increase in dopant concentration. For Ce, doped $BaAl_2O_4$:Eu phosphor the maximum ML intensity is observed at 0.5 mol% concentration of impurity.

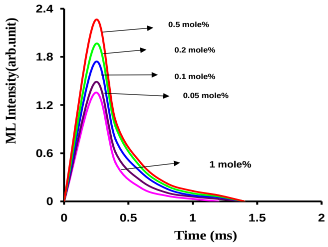

FIGURE 2

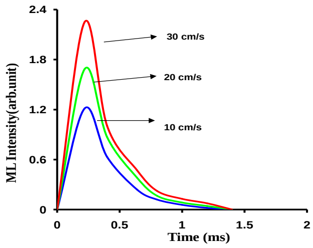

FIGURE 3

Fig.3 shows ML intensity increases with impact velocity and seems to saturate at higher values of impact velocity, however, t_m (i.e. time corresponding to ML peak) shifts towards shorter time value with increase in impact velocity for the all the samples.

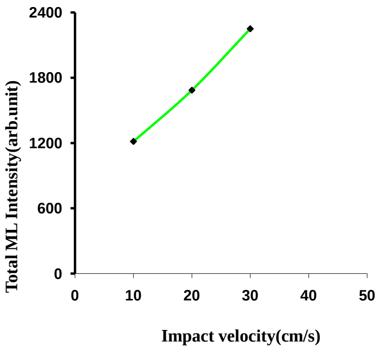

FIGURE 4

Fig.4 shows the total ML intensity initially increases linearly with increasing impact velocity of the piston then it attains a saturation value for higher value of impact velocity for all samples.

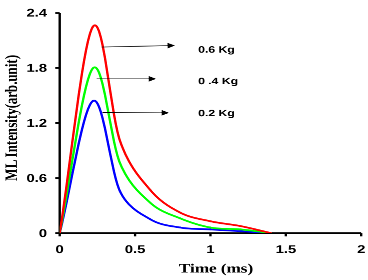

FIGURE 5

Fig. 5 shows the ML intensity increases with increase in mass of the load without any appreciable change in time corresponding to ML peak for all samples.

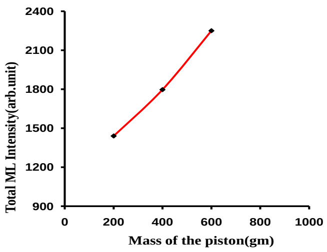

FIGURE 6

In addition, the load dependence of ML was measured. ML peak intensity was found to be linearly proportional to the mass of loaded. The higher mass load the sample was compressed with, the greater ML intensity the sample emitted, as shown in Fig. 6. The slope of the ML curve is the sensitivity of the sample to the load. The intercept value on the load axis (0.2kg) is the minimum stress which can produce detectable ML signal.

In general afterglow originates from emission ions whose photo excited electrons are thermally activated from traps. In our case of $BaAl_2O_4$:Eu ,Ce the divalent Eu ions are excited state under γ irradiation. Part of excited Eu ions return to their ground state immediately and emit light. In such case, the ions cannot return to the ground state and emit instantly. The holes move around in the valence band and can be caught by traps, especially by Ce ions, most efficient trapping centers in the phosphor. The trapped holes can be thermally activated and released from trap to the valance band. This will stimulate a reverse process: The captured electron of the Eu ion returns to valance band to recombine with a hole, and then the Eu ion return to its ground state, and emits afterglow. The activation of trapped holes or electrons can be also activated by other ways, such as infrared light or stress.

CONCLUSIONS

The mechanoluminescence (ML) of $BaAl_2O_4$:Eu, Ce phosphor was investigated. It was found that ML could be only produced by dynamic load. Static load, in the experimental limit, does not affect the decay process of the afterglow of the phosphor. In addition, ML can be induced by both loading and unloading process. Higher sensitivity of ML was observed at longer delay time when the load is applied after shut off the γ irradiation. Based on the results obtained, the source of ML is discussed. It is believed that in the dynamic process of stressing, internal friction originating from defects activates holes released from traps and stimulates mechanoluminescence.

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