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Photoluminescence Comparison of γ-irradiated DyDoped CaWO4 Phosphors

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Abstract:
Photoluminescenc properties of gamma-irradiated Dy activated $CaWO_4$ system have been studied. $CaWO_4$: Dy samples having different concentration of Dy were prepared by solid state diffusion method. Dydoped CaWO4 phosphor has been prepared by solid state diffusion technique and the formation of compound was confirmed by taking XRD pattern. Photoluminescence (PL) emission spectrum of the CaWO4: Dy shows that Dy enters in both Dy^{2+} and Dy^{3+} ionic states in to the lattice. Samples were irradiated with gamma rays using ^{60}Co source. Mechanoluminescence (ML) and thermo luminescence (TL) of gamma irradiated CaWO4: Dy (0.1mol%) phosphors have been studied. A single peak has been observed in ML intensity versus time curve. However, two distinct peaks were observed in ML glow curves of the phosphors irradiated with higher gamma doses. Similarly, in TL glow curve a single peak around 120 °C was observed for the samples exposed to gamma dose 250 Gy. Shoulder appears in the TL glow curve if sample irradiated with higher values of gamma dose.

Keywords: *Thermoluminescence, CaWO4*

1. Introduction

Mechanoluminescence (ML) or sometimes deformation, tribo or piezoluminescence are terms commonly applied to the emission of light by the process of mechanical deformation by rubbing, cutting, compressing, and shaking or by impulsive deformation of a solid substance. Many organic and inorganic crystals, polymers, ceramics and glasses exhibit the phenomenon of ML[1]. The phenomenon of ML links the mechanical, electrical, spectroscopic and structural properties of solids. This technique offers a number of interesting possibilities such as detection of cracks in the solids and for mechanical activation of various traps present in the solids. In general, all the thermo-luminescent materials also show ML during or following their deformation. Tungstates are known to be good materials for radiation dosimetry. CaWO4: Dy is one of the phosphor that is increasingly utilized in thermo luminescence (TL) radiation dosimetry[2]. In recent years a series of magnesium tungstate phosphors have been prepared and their TL characteristics studied and it was proposed that in these phosphors large defect complexes are produced which include intrinsic imperfections and dopants, and these complexes could be regarded as basic elements in TL multistage process[3-5]. In the present investigation the ML of γ-irradiated CaWO4: Dy phosphors have been studied and an attempt has been made to understand the mechanism of ML in this system using their TL and photoluminescence (PL) properties.

2. Methods

CaWO4phosphors containing different concentrations of Dy (0.05-1.0 mole%) were prepared by solid-state diffusion method. CaWO4 and Dy_2O_3 were mixed as per the concentration of Dy ion in CaWO4and crushed for 1 h, then heated at 400 °C for 2 h. The mixture was again crushed for 1 h and fired at 800 °C for 24 h, then slowly cooled to room temperature.All the chemicals used in the present investigation were of AR grade. The XRD pattern of prepared material is shown in Fig. 1. XRD data of prepared CaWO4: Dyphosphor matched well with standard data of JCPDs (File no. 01-072-1259)[6].

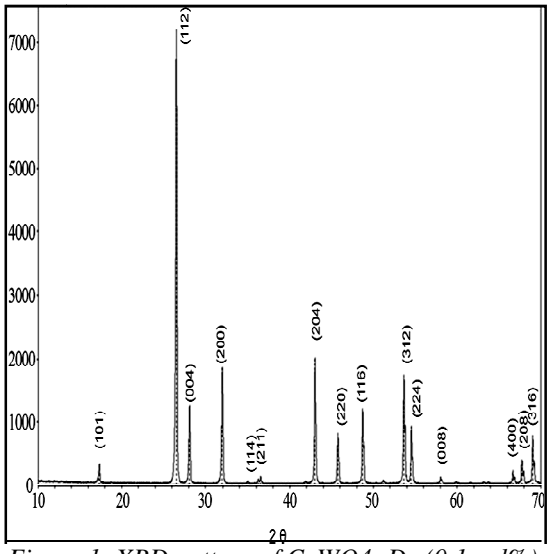

Figure 1: XRD pattern of CaWO4: Dy (0.1mol%)

The prepared phosphors were used for further study. The samples were exposed to γ- rays using ^{60}Co source having dose rate of 930 Gyh^{-1}. The ML was exited impulsively by dropping a load of 0.4 kg onto 1 mg gamma-irradiated phosphor placed on the Lucite plate from the height of 20cm using a guiding cylinder. The impact velocity of the load is determined by the relation $v = \sqrt{2gh}$. The ML was monitored by RCA 931 photomultiplier tube positioned below the Lucite plate and connected to storage oscilloscope. For TL measurements a routine TL set-up (Indotherm) was used and glow curves were recorded by heating the sample with 90 °C/min. The PL emission spectra of the samples were recorded by using fluorescence spectrophotometer (Shimatzu RF-530 XPC). Emission and excitation spectra were recorded using a spectral slit width of 1.5 nm.

3. Results and Discussion

Figure 2 shows PL emission spectrum of CaWO4: Dy (0.1mol%) phosphors in the dose range 232.5 to 1395 Gy. A band around 500 nm was observed. The emissions from 360-440 nm in Dy doped tungstate based phosphors are due to $4F^6 5D \rightarrow 4F^7$ transition of Dy^{2+} ions[7]. It has been reported[8-9] that the Legand field of host affects the Dy^{2+} emission as well as peak position. The emission around 589 nm and 620 nm in Dy doped phosphors are due to $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ transition of Dy^{3+} ions[10].

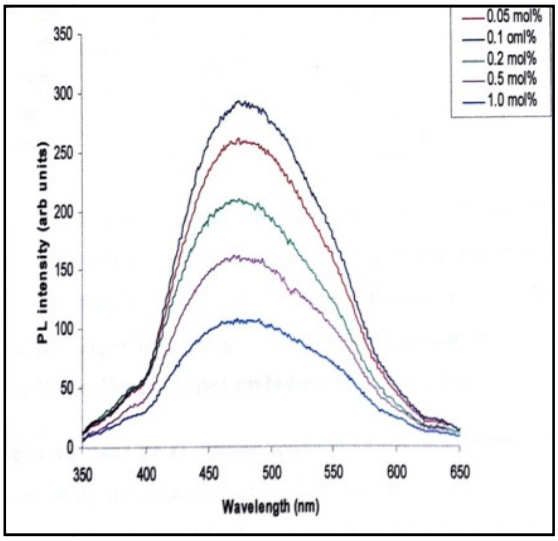

Figure 2: Emission spectra of CaWO4: Dy phosphors with different doping concentration

Figure 3 shows the TL glow curves of gamma irradiated CaWO4: Dy (0.1mol%) phosphors. A single peak around 120 °C is observed in TL glow curve of the sample at a dose level 232.5 Gy. For the samples having higher gamma doses, and high temperature peak at 220 °C arise and peak intensity increases with increasing gamma dose given to the samples. TL emission spectra of phosphors has also been recorded (Fig. 5) and it was observed that the TL emission is characteristics of Dy^{2+} and Dy^{3+} ions. Figure 4 shows the time dependence of ML intensity of gamma irradiated CaWO4: Dy (0.1mol%) phosphors for different gamma dose (232.5 to 1395 Gy) given to the sample.

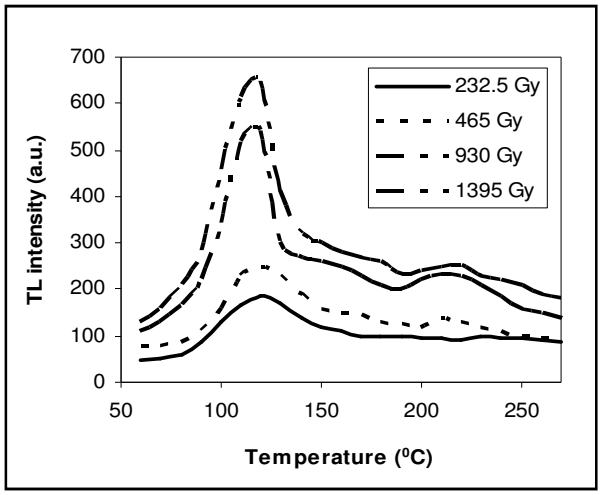

Figure 3: TL glow curve of CaWO4: Dy (0.1mol%)phosphors for different gamma doses given to the samples.

A single peak is observed in ML intensity versus time curve at gamma dose level 232.5 Gy. For higher gamma doses two distinct peaks were observed. ML emission spectrum has also been recorded (Fig. 5) and it is found that the ML emission is characteristics of Dy^{2+} and Dy^{3+} ions. It has also been observed that the peak intensity of the first and second peaks increases with increasing the gamma dose without any considerable change in peak time.

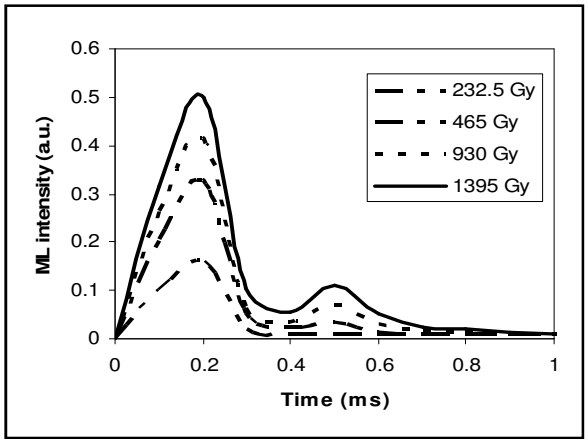

Figure 4: Dependence of ML intensity on gamma dosesgiven to CaWO4: Dy (0.1mol%) phosphors

Zhang et al[4] reported that the main glow peak of CaWO4: Dy phosphors are characteristics of Dy^{2+} ions, however, higher temperature peaks are characteristics of Dy^{3+} ions. In phosphor preparation Dy_2O_3 was taken for doping Dy in to the lattice. During firing phosphors at 800 °C in air some of the Dy^{3+} ions may become Dy^{2+} due to reduction or electron capture. Therefore, characteristics of both Dy^{2+} and Dy^{3+} ions are observed in PL emission spectrum. When the tungstate based phosphors are exposed to ionizing radiation the defect centers like cation vacancies and tungstate radicals are created. On increasing the γ dose, the defect centers increase and thereby the peak TL and ML intensity increases. When the phosphors are heated holes are released and they may recombine with trapped electrons at Dy^{2+} sites subsequent radiation may excite the Dy^{2+} and Dy^{3+} ions present into the lattice and de-excitation of these ions give rise the characteristic emission of Dy^{2+} and Dy^{3+}. Similar to TL mechanism release of holes/electrons from the defect centers might be responsible for ML emission as described elswhere[12].

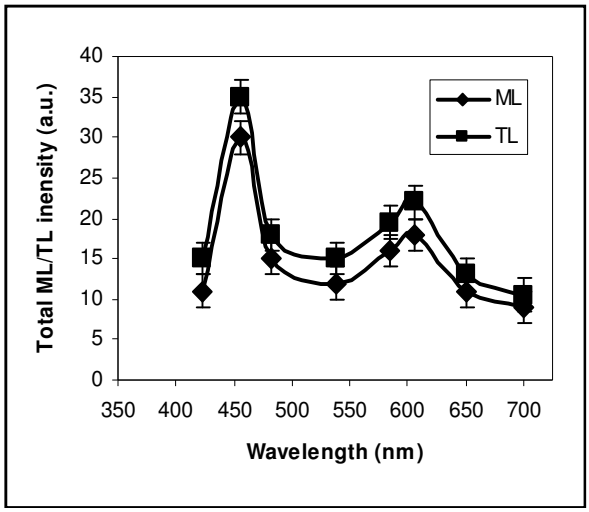

Figure 5: Total TL and ML emission spectra CaWO4: Dy (0.1mol%) phosphors

4. Conclusions

Dy ions act as luminescence centre in CaWO4: Dy phosphors. TL glow curve is complex in nature. Complexity increases with gamma doses. Results indicate correlation between TL and ML.

5. References

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