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Optical properties of calcium aluminate phosphors

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Abstract
Thermoluminescence properties of $CaAl_2O_4$ was studied. It was found that firstly the TL intensity increases with increase in UV irradiation time and it attains a maximum value for 20 minute irradiation time. TL intensity decreases with further increase in irradiation time.

Keywords: Optical properties, Aluminate phosphors

INTRODUCTION

The alkaline earth aluminates are an important class of phosphorescence materials because of their high quantum efficiency in visible region [1], long persistence of phosphorescence, good stability, color purity and good chemical, thermal and radiation resistance [2-3]. The synthesis of oxide phosphors has been achieved by a variety of routes out of which Combustion process is very simple, safe, energy saving and takes only a few minutes. The method makes use of the heat energy liberated by the redox exothermic reaction at a relative low igniting temperature between metal nitrates and urea as fuel. This method appears to hold promise for the preparation of complex oxide ceramics, such as aluminates [4-5]. Thermoluminescence is the emission of light from an insulator or semiconductor when they are thermally stimulated following the previous absorption of energy from radiation [6]. It is very important and convenient method of investigating the nature of traps and trapping level in crystals [7].

In this paper, we prepared $CaAl_2O_4$ phosphor by combustion synthesis method and we report on the Thermoluminescence of this phosphor with the nature of the TL mechanism.

Experimental

Analytical grade calcium nitrate $Ca(NO_3)_2$, aluminum nitrate $Al(NO_3)_3.9H_2O$ and urea $CO(NH_2)_2$ were used as the staring materials. To prepare $CaAl_2O_4$ phosphor starting materials are weighted according to the stoichiometry. Then weighed quantities of each nitrate and urea were mixed together and crushed into mortar for 1 hour to form a thick paste. The resulting paste is transferred to crucible and introduced into a vertical cylindrical muffle furnace maintained at 600°C initiating temperatures. Initially the mixture boils and undergoes dehydration followed by decomposition with the evolution of large amount of gases (oxides of carbon, nitrogen and ammonia). The process being highly exothermic continues and the spontaneous ignition occurs. The solution underwent smoldering combustion with enormous swelling, producing white foamy and voluminous ash. The flame temperature, as high as 1400 - 1600 °C, converts the vapor phase oxides into mixed aluminates. The flame persists for ~30 seconds. The crucible is then taken out of the furnace and the foamy product can easily be milled to obtain the precursor powder.

A routine TL setup (Nucleonix TL 1009I) was used for recording TL glow. Absorption spectra was recorded using Shimadzu UV-1700 UV-Visible spectrophotometer.

RESULTS AND DISCUSSION

The TL intensity of $CaAl_2O_4$ was recorded after irradiation with UV light for different interval of time which has one peak at 280 °C suggesting existence for trapping level. TL intensity increases with increase in UV exposure time and it is maximum for irradiation time 20 min. Further increasing exposure time, TL intensity decreases. The variation in TL intensity with irradiation time is shown in Fig.1. The trap depth was calculated using different methods. Fig.2 shows the calculation of trap depth using initial rise method which came out to be 0.11 eV. These traps are hole traps which are much higher than the thermal energy of 350K (0.03 eV) hence could not be thermally activated at room temperature. When sample is heated, heat excited the filled traps (T^+) to release holes to the valence band and subsequent recombination of the electrons and holes in luminescence centers (L).

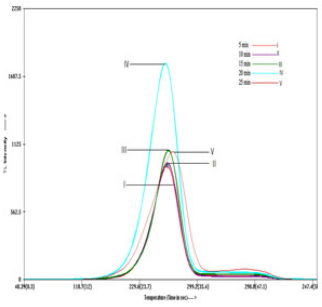

Fig. 1. TL intensity Vs Temperature plot for different time of irradiation

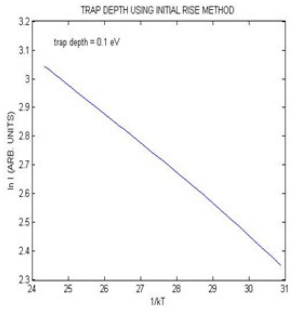

Fig. 2. Calculation of trap depth by initial rise method

The process can be explained as below

$$H + T^+ \longrightarrow H + T + h^+$$
$$h^+ + L \longrightarrow L^* \longrightarrow L + h\nu$$

With irradiation there is formation of colour centers, which increases with increase in irradiation time. Further irradiating the sample, bleaching of colour centers takes place and hence TL

intensity decreases.

CONCLUSION

We have investigated the Thermoluminescence phenomenon in $CaAl_2O_4$ for different irradiation time. It was found that the TL glow curve is broad curve and it has maximum at 280°C. With increase in irradiation time the TL intensity increases, which is maximum for irradiation time 20 minutes. Further increasing the irradiation time TL intensity decreases.

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