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Spectral distribution and brightness wave forms of the electroluminescent ZnS: Cu, Sn luminophor

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The effect of voltage and frequency on the spectral distribution of ZnS : Cu, Sn phosphor has been investigated. The electroluminescent emission spectrum consists of a single band in the region 4000-6000Å. The peak of the electroluminescent spectral band shifts towards shorter wave length side by increasing the frequency of the exciting field, but it remains unchanged with the increase or decrease of the applied voltage. The brightness wave forms of this phosphor has also been studied at different voltages and frequencies of the applied field. One primary and one secondary peak has been observed in each half cycle of the applied sinusoidal voltage. The results have been discussed in the light of the existing theories.

1. INTRODUCTION

It is now well known that with the addition of impurity in the controlled amount, the ZnS becomes photoluminescent and under specific conditions of preparation, it also acquires the property of electroluminescence. Now a days, electroluminescence may be produced in any desired region of the electromagnetic spectrum by a proper choice of a base lattice, donor-acceptor pair and the energy absorbing interphase. The light emission inside the ZnS lattice very much depends upon the relative concentration of the activator and the co-activator ions, the firing temperature and the preparation technique etc.

Apart from the investigations like voltage, frequency and temperature dependence on the intensity of the emitted light, the study of spectral distribution and the brightness wave forms is also important for understanding the mechanism of electroluminescence. The present communication reports for the first time effect of voltage and frequency of the applied a.c. field on the spectral distribution and the brightness wave forms of a new ZnS : Cu, Sn luminophor.

2. EXPERIMENTAL

Electroluminescent sample was prepared by firing the raw mixture, containing copper as activator and tin as coactivator, at a temperature of 950°C for 90 minutes in a tubular furnace under the continuous flow of pure nitrogen gas. Details of sample preparation have already been described by Maheshwari &

Khan (1974), in earlier publication. A permanent type of electroluminescent cell was used. One electrode of this cell was a plano polished Al sheet and the other was a transparent conducting glass plate, having resistance ~ 100Ω/cm². The sample in fine powdered form was mixed in araldite and was put pressed between the two electrodes. A. C. voltages in the audio frequency range were developed using an audio-oscillator (range 50 Hz to 200 KHz) coupled with a wide band amplifier (range 0 to 750V (rms)) and were applied to the electroluminescent cell.

The wave forms of the light output and the applied field were traced simultaneouly on the screen of a cathode ray oscillograph in stationary positions. The study of the electroluminescent spectral distribution was made by using a prism monochromator, stabilized d.c. power supply, a multiflex galvanometer and a RCAIP21 photomultiplier tube. The photomultiplier tube was calibrated with the help of tungusten filament lamp of known colour temperature.

3. Results and Discussion

The spectral distribution of electroluminescent brightness at 500 volts (rms) and at different frequencies of the applied sinusoidal field is shown in figure 1. From this figure we observe that (*i*) the light emission extends from 4000 to 6000Å, (*ii*) the phosphor shows only one distinct maxima at each frequency, (*iii*) by increasing the excitation frequency, the peak of the light emission shifts towards shorter wave length side.

The spectral band does not shift with the increase or decrease of the voltage of the exciting field as shown in figure 2.

A complete explanation of the frequency dependence of electroluminescent spectral emission can be given with the help of the Schon (1942) Klasen's (1946) model. When an alternating electric field is applied, the luminescent centres are ionized and the freed electrons move to the conduction band and are held there on the positive side of the phosphor till the expiry of the field. In the mean time some electrons from the valence band go to the vacant low lying centres. At low values of the applied field frequency (the time period being large) all the vacant low lying centres are filled by the electrons from the valence band, therefore, the recombination of electrons of the conduction band takes place at higher centres only. This gives rise to emission at low energy i.e., towards higher wave length side. At higher frequencies of the applied voltage (the time period being small) some of the low lying centres will remain vacant therefore, the recombinanation of excited electrons takes place at low lying centres. This gives rise to emission in the higher energy region i.e., towards shorter wave length side. Thus there is a shift of spectral band towards shorter wave length side with the increase of the frequency of the applied field.

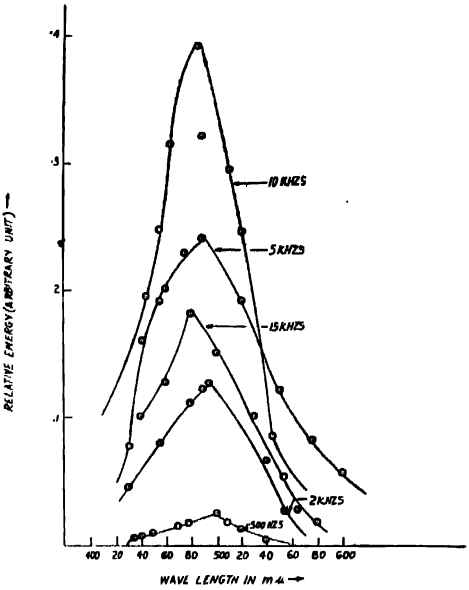

Fig. 1. Spectral distribution of electroluminescent brightness of ZnS : Cu, Sn phosphor at different frequencies (at 500V)

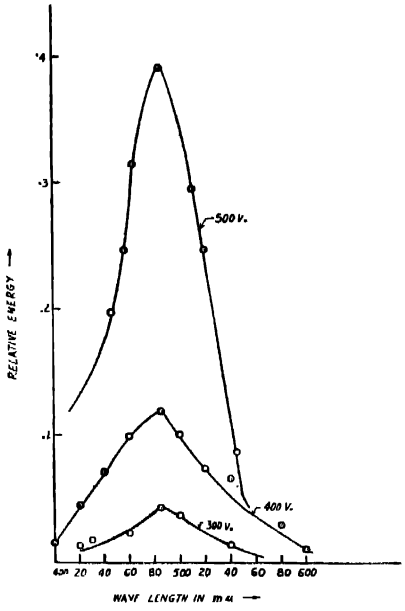

Fig. 2. Spectral distribution of electroluminescent brightness of ZnS : Cu Sn phosphor at different voltages (at 10KHz frequencies).

The experimental results have been found to be explained well with the Schon-Klasen model of luminescence, thus we conclude that the luminescence emission is due to electron transitions from the conduction band into the discrete localized levels (luminescent centres) as discussed earlier.

The variations of the integrated light output and the applied sinusoidal voltage vs time at (a) 500 Hz : 400V, (b) 1KHz; 500V, (c) 2KHz: 400V; 600V, (d) 5KHz: 400V, (e) 8KHz :300 V; 400V and (f) 10 KHz :400V are shown in figure 3. From the figure we observe that (*i*) the primary peaks of the brightness waves lag in phase with the applied sinusoidal voltage (ii) there exist one primary and one secondary peak in each half cycle of the applied voltage (*iii*) at a fixed frequency, with the increase of the applied voltage the secondary peaks become better pronounced.

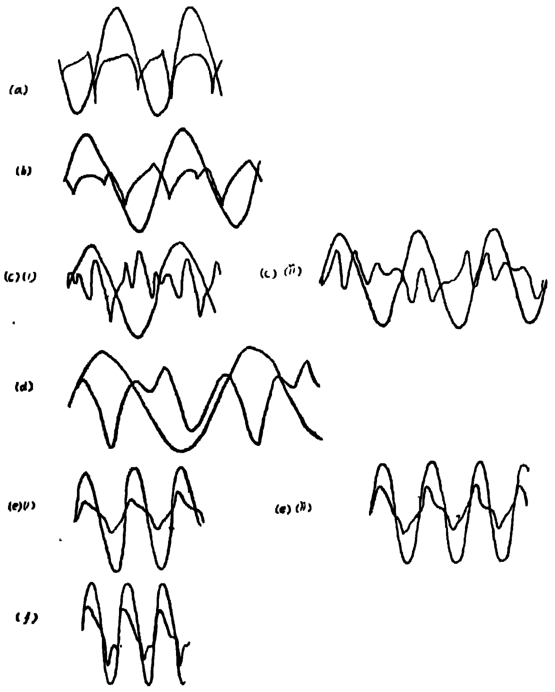

Fig. 3. Electroluminescent birghtness wave-forms of ZnS : Cu, Sn, luminophor at (a) 500Hz, 400V (b) 1KHz, 500V; (c) (i) 2KHz, 400V, (ii) 2KHz, 600V; (d) 5KHz, 400V; (e)(i) 8KHz, 300V, (ii) 8KHz 400V & (f) 10KHZ, 400V.

From earlier investigations of Destriau (1956) and Curie (1963) it is well known that the sinusoidal electric field E_d in the dielectric around the phosphor grains lags in phase with the field E_p on the phosphor. The phase lag between the two is given by

$$\tan \phi = \frac{4}{K\rho\omega} = \frac{2}{K\rho f},$$

where K represents dielectric constant of the phosphor and ρ its specific resistance.

Recently it has been observed by Ivey (1963), Singh & Mohan (1969) that the field inside the dielectric lags in phase also with the applied sinusoidal voltage V in a complex manner. In our case since the amount of phosphor is less than the mass of the dielectric, so E_d will be in phase with E_p and thus the same phase difference ϕ will exist between the brightness wave and the applied sinusoidal field.

The appearance of the secondary peaks may be due to delayed transition of electrons from the deeper trap levels to the fundamental Cu level. Since more excitation energy is required for these transitions to occur, therefore, at high voltages the secondary peaks start appearing.

The prominence of the primary peaks than the secondary peaks at low applied voltage suggests that in this phosphor deeper trap levels are less in number.

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