Research Article

EFFECT OF TEMPERATURE ON THE BRIGHTNESS OF ZnS:Mn THIN-FILM ELECTROLUMINESCENT DEVICES

Sanjay Tiwari[1], U.K. Jain[2] and *Rameshwar Tiwari[2]
[1]*S.O.S. in Electronics, Pt. Ravi Shankar Shukla, University, Raipur (C.G.) 492010,*
[2]*Department of Physics, Govt Postgraduate College, Chhindwara (M.P.), India*
*Author for Correspondence

ABSTRACT
Electroluminescence efficiency and brightness depends on the temperature. At low temperature, electroluminescence efficiency remains constant but at higher temperature it decreases due to thermal quenching. The brightness was found to be a monotonically decreasing function of temperature. The saturation value of the EL brightness decreases with increasing value of the temperature of the EL device.

Key Words: Electroluminescence, Tunneling Effect, Electric Breakdown, Alumel-Chromel Thermocouple

INTRODUCTION
In considering the reliability of thin film EL devices, three important factors must be taken into account:
Electrical reliability with respect to electric breakdown
Long time reliability
Shifts in luminance-voltage characteristic curve with operation
Display resistance to environmental stresses such as pressure, temperature and temperature/humidity is very important to assure EL device reliability. The characteristics of a non-operating thin-film EL display are unaffected when subjected to temperature extremes from -55 to 125°C. Thin film EL display systems with materialized electronics have been designed to operate over the temperature range of – 40 to 85°C.

The temperature dependence of electroluminescence (EL) is interesting not only because it modifies the EL emission but it yields information to understand the nature of the phosphors and the effective trap-depths may be determined. Destriau (1947) was probably the first who studied the temperature dependence of ZnS-ZnO phosphors and observed that the threshold voltage of excitation falls as the temperature is lowered.

A small effect on the EL brightness was observed by Roberts (1952) when the temperature was varied between –100°C and +50°C and concluded that output does not depend on a thermal activation. Many workers (Thornton 1956, Haake 1957) have observed that electron trapping is very important in determining the output and other characteristics of electroluminescence. Since electrons released from luminescence centers during one half-cycle of the applied voltage will be swept way by the field and can return only after the direction of field has been reversed, it is expected that in the mean time they may become trapped in the low field region of the crystal.

Mattler (1956) and Haake (1957) have emphasized that in studying the effect of temperature on electroluminescence care should be taken to avoid complications resulting from changes with temperature of the properties of the dielectric used to embed the phosphor. Cuire (1952), Haake (1957) and Alfrey (1956) have shown that the effect of temperature on the electroluminescence output also be separated from recombination process. It is known that, at low temperature, photoluminescence efficiency remains constant but at higher temperature it decreases due to thermal quenching. The electroluminescence output should, therefore, also be expected to decrease at high temperature for the same reason. Haake (1957) observed two peaks in electroluminescence output. These peaks are produced by the combined effects of electron liberation from a set of trapping levels. Alfrey and Taylor (1995) have pointed out the influence of temperature on recombination due to electron trapping in low field region.

Gobrecht *et al.*, (1954) observed an irreversible effect of the temperature dependence of electroluminescence output of ZnS powders. When the temperature was raised, a series of peaks,

Research Article

resembling the thermo luminescence curves were obtained. This effect has been called "electroluminescence''. Hahn (1956) studied this effect further and pointed out that his phenomenon may be due to nature of the embedding material. The effect is not genuine because it is observed only in poorly emitting phosphors. According to Dimer *et al.,* (1954), the free electron for exciting the luminescence centers appear as a result of a tunneling transition through a potential barrier. It is assumed that such a transition is not direct and involves phonons so that probability for such transition varies with temperature.

The present paper reports the effect of temperature on the brightness of ZnS : Mn thin-film electroluminescent devices.

MATERIALS AND METHODS
For studying temperature dependence of the brightness, the electroluminescent thin film devices was placed on copper disc, attached with one hollow tube containing heating filament. The heating filament was connected to a relay and operated by a variac so that one can maintain the desired temperature. The temperature was measured with the help of an alumel-chromel thermocouple. A varying AC voltage of different frequencies was applied to cell and the brightness of electroluminescence emission was measured in arbitrary units.
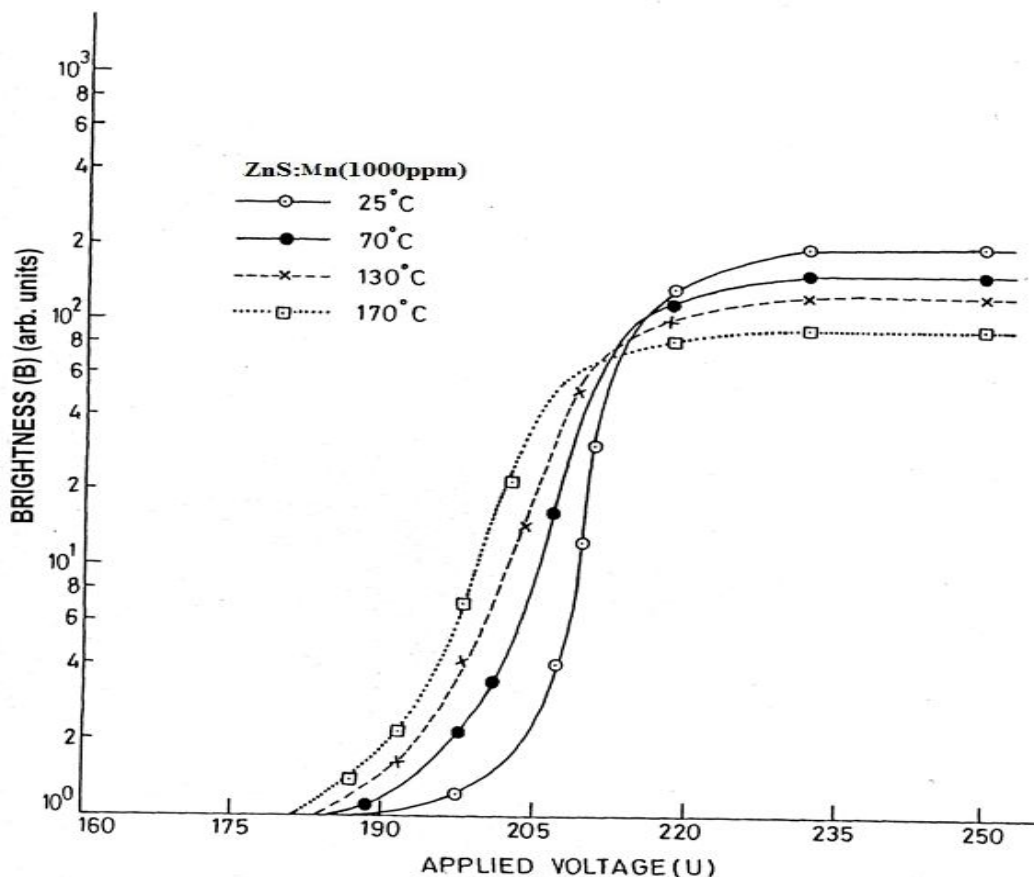
RESULTS

Figure 1: Dependence of EL brightness (B) on the applied voltage Up of ZnS:Mn (1000 ppm)   for different temperature

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Figure 1 shows the dependence of EL brightness (B) on the applied voltage U_p for ZnS:Mn for different temperatures. It is seen that the EL starts beyond a particular voltage, then it increases with voltage and tends to attain a saturation value for higher value of the applied voltage. It is evident that the saturation value of the EL brightness decreases with increasing value of the temperature of the EL device. Furthermore, the threshold voltage also decreases with increasing value of the temperature.

Figure 2 shows the dependence of EL brightness on the temperature of EL device for different concentrations of activator in the phosphors. It is seen that the EL brightness decreases with increasing temperature of the sample and decrease of brightness with temperature is faster for the phosphor having higher concentration of the activator.
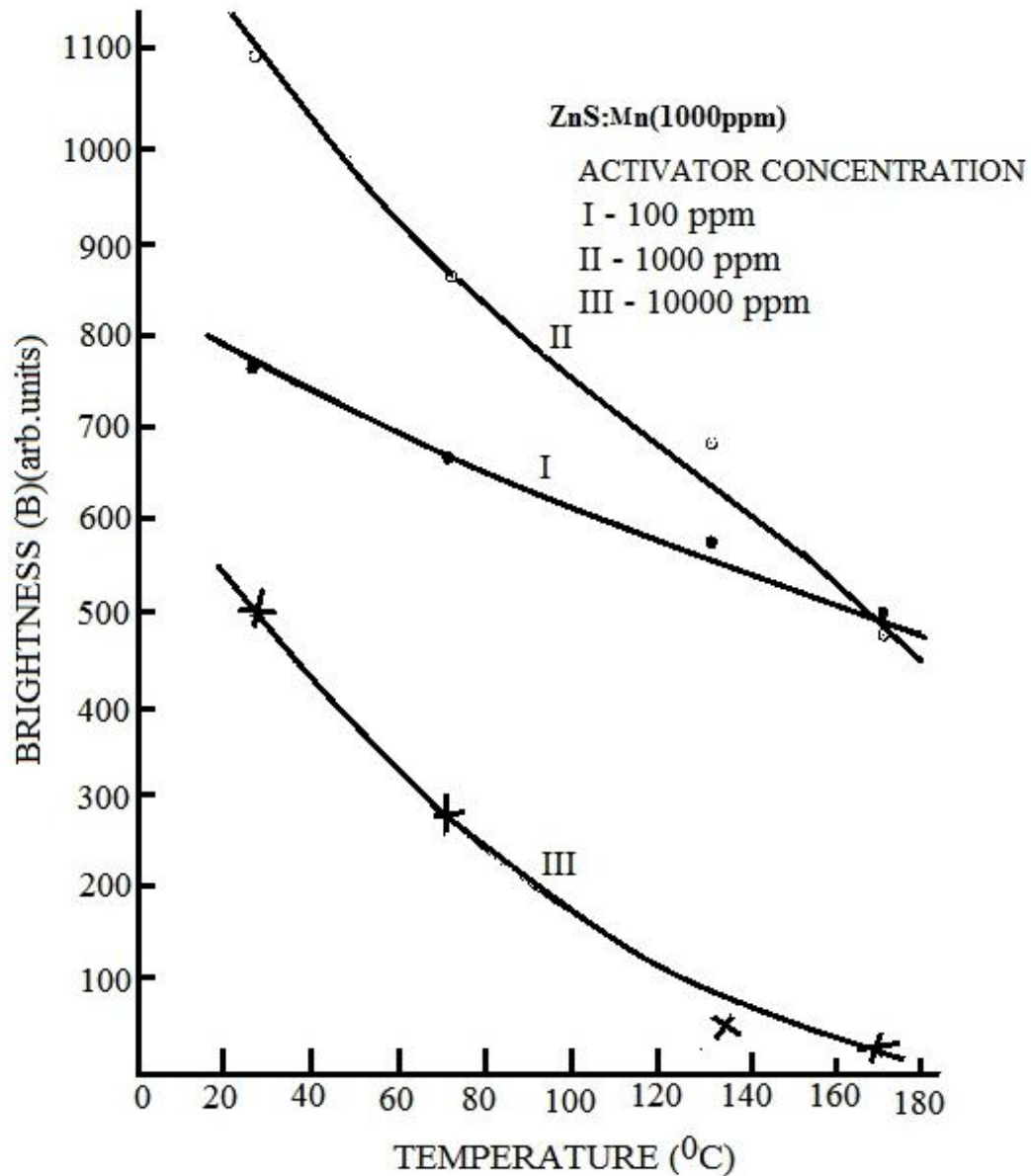

Figure 2: Dependence of EL brightness on the temperature of EL device for different concentrations of activator in ZnS:Mn phosphor

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DISCUSSION

First investigation of the temperature effect in ac TFELDs was reported by Yang *et al.,* (1981). The brightness was found to be a monotonically decreasing function of temperature. In order to clarify the physical mechanism of this effect, Mach and Muller (1982) studied the influence of temperature on brightness and dissipative current (measured by the transferred charge ΔQ).

Mach and Muller (1982) measured the transferred charge or polarization P_n at the corresponding brightness as a function of temperature. It is found that the polarization is only very weakly dependent upon temperature. This fact rules out the possibility that the decrease of B with increasing temperature could be caused mainly by a variation of the number of hot electrons. It may rather be due to a variation of the ratio of radiative to non-radiative processes with temperature. This fact is further supported by the investigation of the temperature dependence of the electroluminescence decay time (Mach and Muller 1982). Mach and Muller (1982) have also shown that the hysteresis loop voltage is nearly independent of temperature for 1000 K < T < 350 K, but decreases drastically above this temperature due to an increasing leakage current of the devices.

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