

Electroluminescence Studies of Zinc Selenide Doped with Mn Phosphors

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Abstract

Electroluminescence and Electro photoluminescence are concerned with the effects of electric field on the luminescent emission of phosphors. Electroluminescence is the more specific term and refers to the light emitted by a suitable phosphor when an electric field is applied to it. The phosphor can be in the form of a polycrystalline layer or a single crystal. The conducting electrodes, one of which should be transparent in the case of polycrystalline layers, can either be laid directly on the phosphor or separated from it by dielectric medium. Electroluminescence is a rather loose term which embraces a large number of different phenomena which occur in luminescent materials when an electric field is applied during or after the excitation by optical means. This electrophotoluminescence refers to the combined effects of optical excitation and an applied electric field. In a sense Electroluminescence in which the effects of electric field alone are considered.

KEYWORDS: Luminescence, Electroluminescence, Emission of photons, phosphor.

1. Introduction

There are thousands of known luminescent materials but the number of known electroluminescent materials are much less. Although there are probably several mechanisms by which EL can occur, distinction is currently made between the following two principal processes¹:

- (i) Minority carrier injection at a metal contact or P-N junction followed by recombination of free electrons and holes with emission of photons, and
- (ii) Excitation of luminescent activator centers by energetic electrons accelerated in a very high electric field localized at some potential barrier followed by emission of light when empty activator centre captures a free electron.

2. Experimental

There are three important part of experimental arrangement

2.1 Preparation of Conducting Glass Plate

A conducting electrode is prepared by depositing a transparent conducting thin film on a glass plate, for which we have utilized the method suggested by Gomer². The glass plate of appropriate size were heated slowly up to 500-600⁰C by placing them on a thick

metallic plate and the vapors of SnCl_2 were sprayed onto the heated glass plate in presence of air by using the apparatus shown in Fig.1

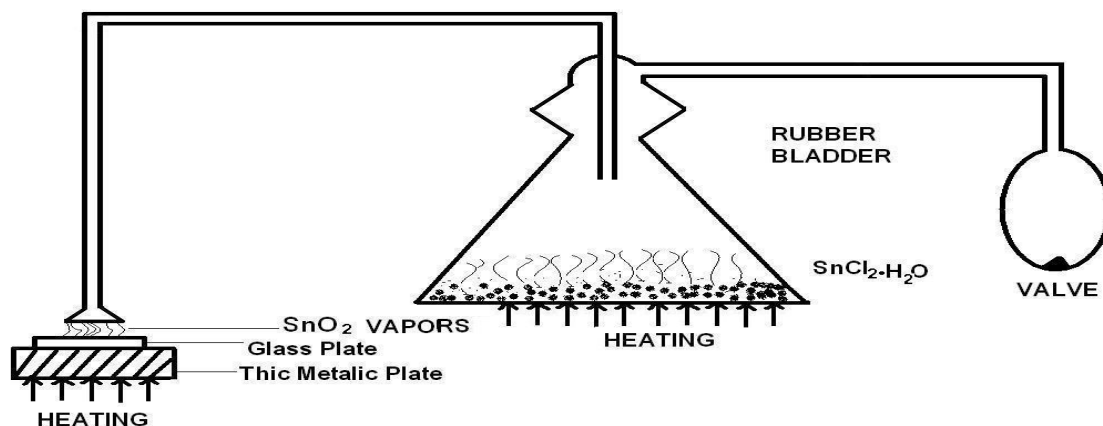


Figure 1. Experimental arrangement for the preparation of conducting glass plate

The device consists of a conical flask in which the crystals of powders of $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ were placed and heated to vaporise SnCl_2 . The vapors were blown towards the glass pate by giving a number of puffs to the rubber bladder connected to the flask. The vapors of SnCl_2 mixed with air were deposited on the surface of heated glass plate as SnO_2 . This procedure was repeated until the desired results were obtained.

2.2 Electroluminescence Cell

The electroluminescence cell, shown in Fig. 2, consists of two plane parallel electrodes: one of which should be transparent in order to see the luminescence. Between the two electrodes a dielectric is inserted; in the present case a mica sheet was utilized. Electroluminescent powder is placed between the transparent electrode and the dielectric.



Figure 2. Electrode configuration of an Electroluminescence cell

The dielectric medium in which the phosphor powder is dispersed should be reasonably translucent, chemically inert and should have a high dielectric constant, so that it sustains only a small fraction of applied voltage. The dielectric mediums used by different workers are plasticized liqueur with castor oil, melamine formaldehyde and alkyl resins, etc. In the present study araldite and mica were used as the dielectric medium, since their dielectric constants do not change appreciably with temperature.

The phosphor was dispersed in araldite and the paste was spread over the circular aluminium electrode. Some araldite was spread over the mica sheet also and the conducting surface of the glass plate was pressed gently to avoid the gas discharge. For maximum EL brightness, the layer should be uniform and thin. A compromise thickness was achieved by placing a weight of 1 kg over the conducting glass plate which pressed the phosphor paste against the glass plate.

2.3 Source of Excitation

A high alternating or pulsating voltage is required to excite EL. In Present Studies, an AC voltage was utilized for this purpose

(i) Oscillator: A Sinusoidal oscillator was used. This controls the alternating voltage delivered by a wide band amplifier.

(ii) Wide band high voltage amplifier: A wide band high voltage amplifier was used. Frequency of the input could be varied from 20 Hz to 20 KHz by changing frequency of the audio oscillator. This output voltage could be increased up to 1,000 volts (rms) by increasing the output of the audio oscillator.

(iii) Photomultiplier tube: The intensity of light was measured by RCA 931 photomultiplier tube which was operated by a regulated power supply at 900 volts.

4. TECHNIQUE OF MEASUREMENT:

The arrangement for measurement of voltage and frequency dependence is shown in Figure 3. The light emitted by the EL cell was recorded at different frequencies and voltages by a photomultiplier tube. For measuring the intensity of light, output of the photomultiplier tube was fed to a nanometer which measures the EL brightness in terms of electric current.

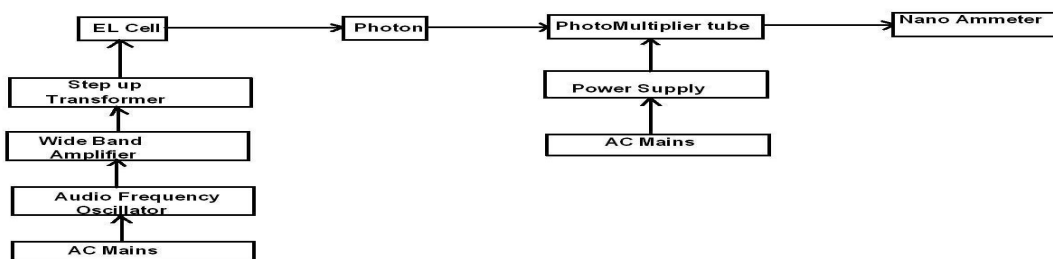


Figure 3. Experimental arrangement for the measurement of voltage and frequency dependence of EL brightness

For measuring the EL spectra, the cell was placed near the entrance slit of a grating monochromator, near the exit slit of the monochromator, a RCA 6199 photomultiplier tube was placed whose output was connected to a digital Pico ammeter. By changing the drum of the monochromator, the light of any wavelength could be obtained from the exit slit and measured. In this way the EL brightness could be determined for different wavelengths which in turn gave the EL spectra.

5. RESULTS:

The voltage dependence of EL brightness of ZnSe:Mn (having activator concentration 5,000 ppm) is shown in Figure 4.

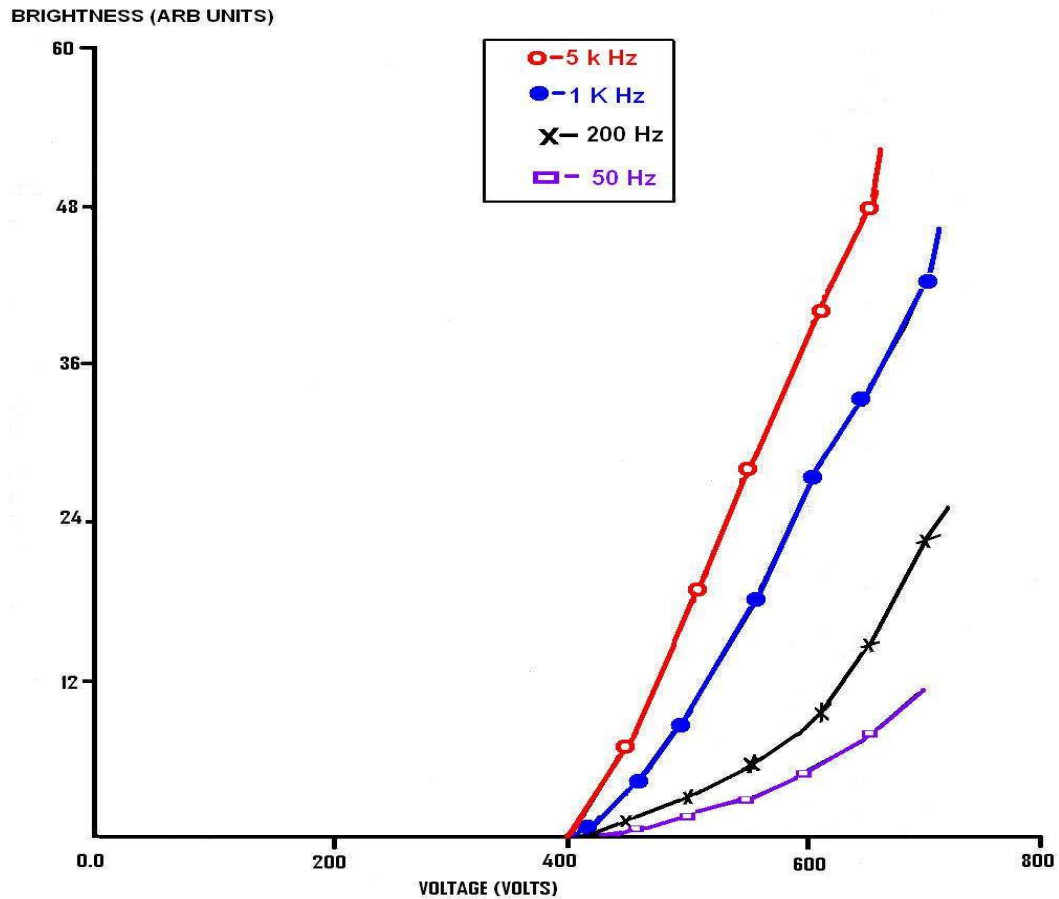


Figure 4. Voltage dependence of EL brightness of ZnSe:Mn Phosphor at difference frequencies.

For different frequencies of the applied electric field. It can be observed that the brightness increases with the applied voltage at a given frequency. Figure 5 shows that the plot of log of brightness vs $100\sqrt{V}$ is a straight line with a negative slope, which suggests the relation $B = B_0 \exp(-b/\sqrt{V})$ where B_0 and b are constants.

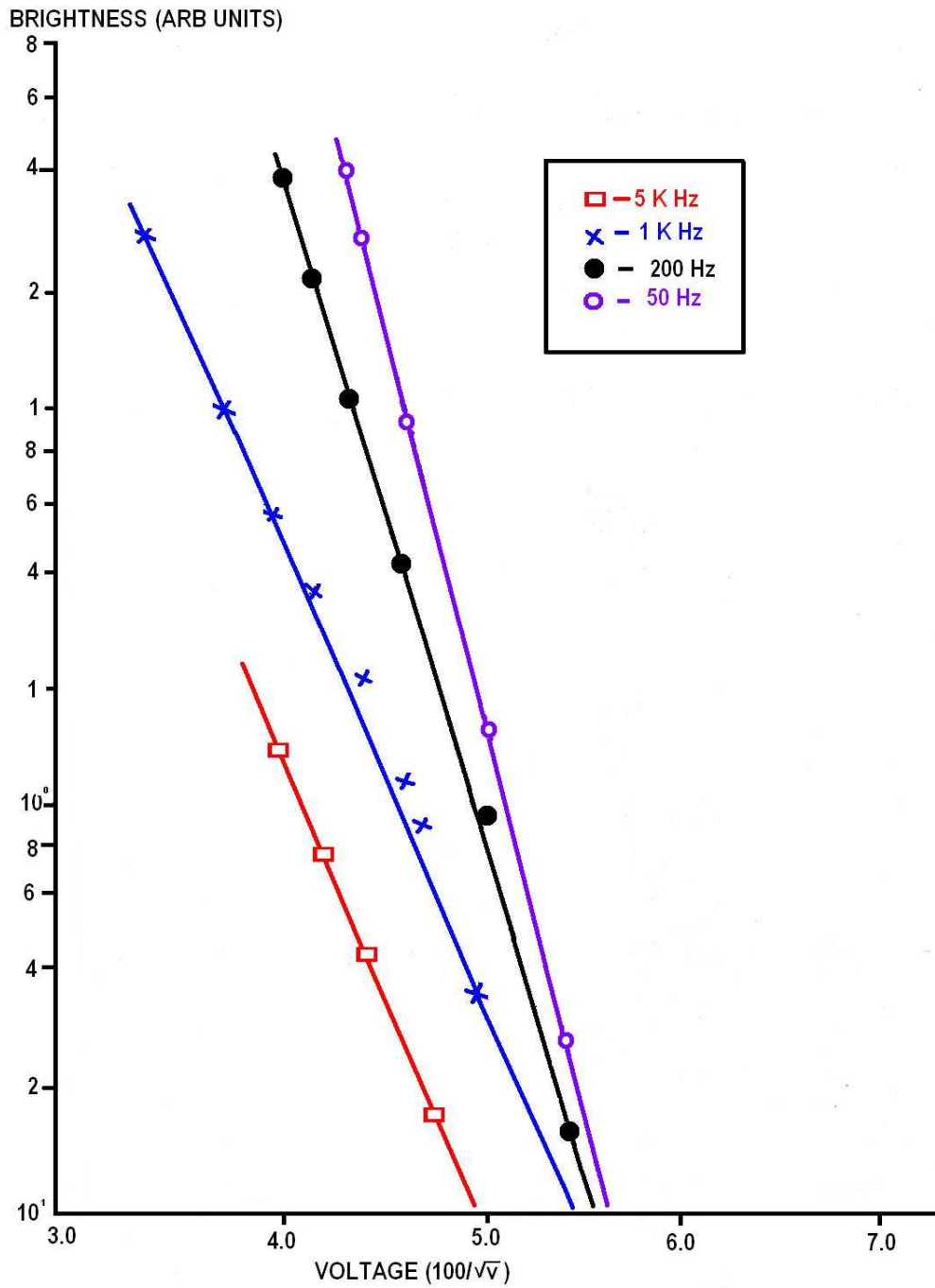


Figure 5. Voltage dependence of EL brightness of ZnSe:Mn phosphor at different frequencies.

The frequency dependence of the EL brightness for different voltages is shown in Figure 6. It is evident that the EL brightness increases with increasing frequency of the applied voltage.

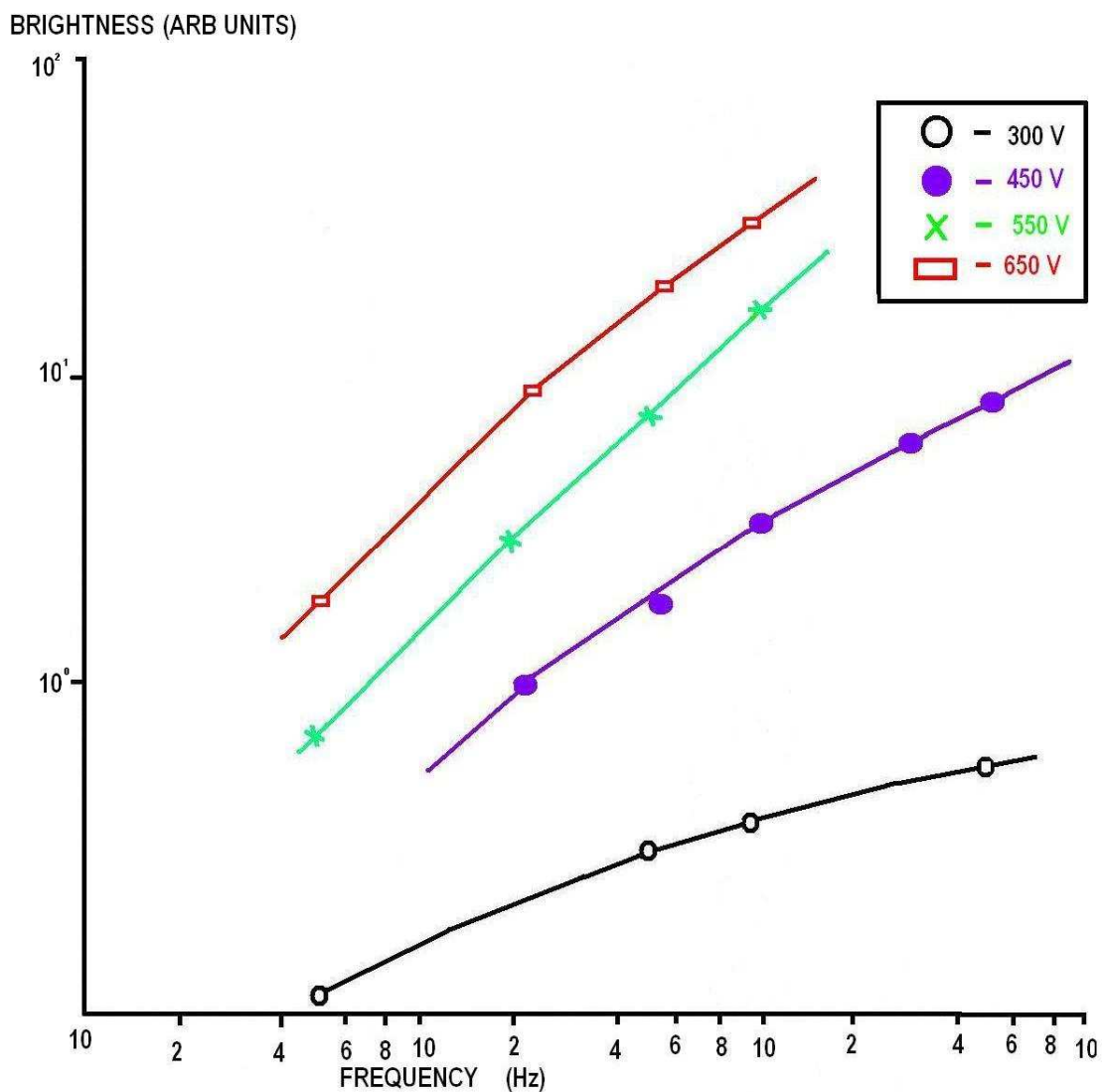


Figure 6. Frequency dependence of EL brightness of ZnSe:Mn phosphor at different voltages.

6. DISCUSSION:

The increase in the EL brightness with frequency can be understood on the basis that emptying and refilling of the EL centers take place more rapidly with increase in frequency. But when the time period at applied ac cycle becomes comparable to the life time of excited electrons, the electron does not have sufficient time to emerge out from the trap and the time averaged brightness does not increase linearly with frequency. By

considering the rate of recombination to be determined by field controlled release of electrons from trap, the brightness as given by Ivey¹ is

$$B=N_0f [1-\exp (-A/f)]$$

Where N_0 has been assumed as a constant number of excited centers for each half cycle of voltage and A increases as voltage increases. At higher frequencies the time averaged brightness becomes equal to N_0A , i.e. a saturation of brightness occurs. The depletion of ionized activators does not occur during a cycle at lower voltage and therefore N_0 becomes frequency dependent and hence the curves become more linear at higher voltages.

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