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A Study of Electro and Photoluminescence Properties of Some Inorganic Phosphors, ZnSe:Pb , ZnSe :Sm And ZnSe (Pb,Sm)

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Abstract

Electroluminescence and Photoluminescence properties of (ZnSe):Pb ,ZnSe : Sm and (ZnSe): (Pb,Sm) phosphors are explained in this paper .The phosphors are prepared in the nitrogen gas atmosphere with different concentration and suitable doping.

The EL brightness varies according to the relation,

$B=Bo\ \exp\ (-\ \frac{b}{\sqrt{V}})$ showing the acceleration collision mechanism to be effective for this system. The brightness of photo luminescent spectra varies with different wavelengths and concentration.

Introduction

Luminescence is defined as the emission of stored

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energy in the form of radiation falling in visible, near infrared and ultraviolet regions from a material, called phosphor, as a result of some sort of excitation. [1,2].

Phosphors

Materials exhibiting the properties of light emission as a result of excitation are called phosphors. These are generally organic or inorganic solids in the form of single crystal or microcrystalline powders.

Photoconducting phosphors

Such phosphors show photoconductivity during the luminescence process e.g. ZnS, ZnSe and CdS phosphors.

Non- photoconducting phosphors

This group of phosphors does not show photo conductivity under normal conditions of excitation. These are the materials which absorb quanta of energy lower than 1eV from the excitation source and convert a portion into detectable photon emission.

Electroluminescence

Electroluminescence is an optical phenomenon and electrical phenomenon in which a material emits light in response to the passage of an electric current or to a strong A.C. or D.C. electric field.

Photo luminescence

Photoluminescence is light emission from any form of matter when it is excited by photons such as infrared, visible, X rays or ultraviolet rays.

For studying the luminescence properties of the

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materials doped with activator and co-activator ions [3] we have prepared and studied various properties of (ZnSe) phosphors activated with Pb^{+2} and Sm^{+3} ions. The present study gives the electroluminescence and photoluminescence properties of these phosphors.

Theory

The time averaged light output of the EL cell depends on a large number of factors like the composition of the phosphor, the dielectric medium, particle size, temperature, nature of contacts and on the voltage and frequency of the applied field. The brightness (B) varies with applied voltage

$$B=B_0 \exp\left(-\frac{b}{V+Vj}\right)$$

Where B_0 ,V_j and b are constants

In a large number of phosphors, the relations are

$$B=B_o \exp\left(-\frac{b}{\sqrt{V}}\right)$$

Field Ionization

An electric field can excite the crystal directly by tunnel transfer of electrons from the valence band and also from the luminescence centres to the conduction band. The tunnelling through the potential barrier was considered by Zener [4]. The probability per unit time for ionization of electrons from the V.B to C.B. in the field E is given as

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$$P_i = \frac{eEd}{2\pi\hbar} \exp\left[-\frac{\pi(2m')^{1/2} E_g^{3/2}}{4\hbar eE}\right]$$

Where E is the electric field, e and m' are the charged and effective mass of an electron, E_g is the band gap and d is the lattice constant.

Ionization by Impact

In this mechanism the electrons are accelerated in the conduction band by the electric field until they get sufficient energy from the field to excite the center by in elastic collision. The raising of electrons in the conduction band is followed by an acceleration collision mechanism of electroluminescence. The probability of excitation [5] is given by

$$P \propto \exp(-E / KelF)$$

where E is the energy required, I is the mean free path and F is the field strength.

The charge carriers are accelerated under the influence of following conditions that must exist to produce the electro luminescence by the elastic collisions of high field electrons and activator systems.

1. Raising of electrons into the conduction band for acceleration
2. Acceleration of these electrons by the field
3. Collison of these electrons are transfer of their kinetic

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energies with the centres and finally the radiative or non- radiative recombination of electrons with centres will occur.

Experimental methods

Appropriate quantities of ZnSe, $Pb(C_2H_3O_2)_2.3H_2O$, Sm_2O_3 were well mixed in desired proportions to get ZnSe:Pb, ZnSe:Sm, ZnSe:(Pb,Sm) phosphors. A constant amount of 1 mole percent NaCl was used as a flux in each phosphor. Each sample was fired at 780±20C for one hour in a nitrogen gas atmosphere. The electroluminescent cell (EL cell) is normally prepared by pressing the mixture of the phosphor with castor oil in equal quantities between the conducting glass plate and a polished plane aluminium plate made insulated by a thin mica sheet of ≈ 10μ thickness so that the phosphor was not contact with the aluminium plate (fig a). In the whole process to ensure that there are no air bubbles remaining in the paste.

The effect of voltage on EL intensity at the particular frequencies have been observed by the varying of voltage applied to the EL cell with the help of an oscillator. The intensity was recorded in terms of deflection of spots on the linear scale.

For frequency dependence, the applied voltage on the EL cell was kept constant and the intensity was recorded by varying the applied frequency. The block diagram for EL measurement is shown in fig b.

The PL excitation was done by 3650 A^0 radiation from a high pressure mercury lamp operated at a constant

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voltage. A constant deviation spectrograph, with an accuracy of 10A was used as a monochromator for studying the spectral distribution of the luminescence emission. The light emitted from the phosphor was detected by an IP 21 photomultiplier tube operated on a regulated power supply; the time averaged photo current was measured by a multiflex galvanometer in arbitrary units (

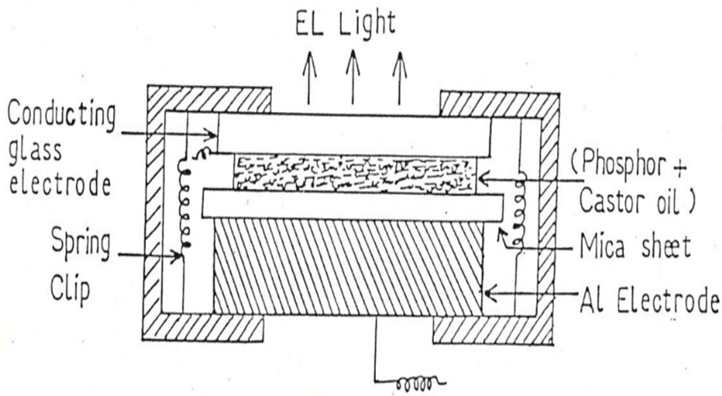

fig a STRUCTURE OF EL CELL

A.U).

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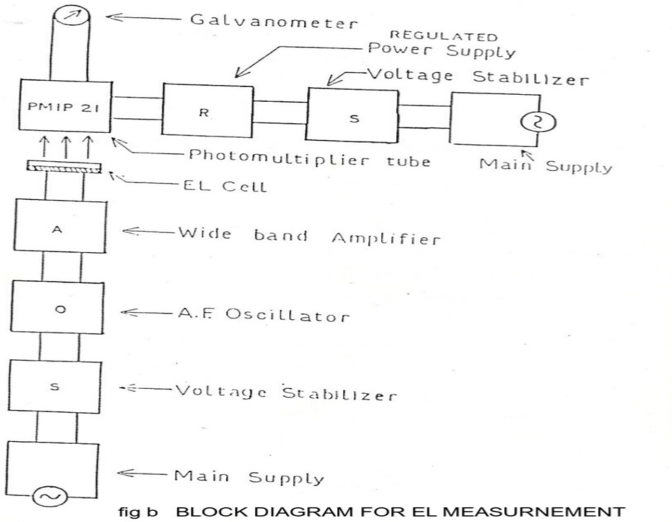

fig b BLOCK DIAGRAM FOR EL MEASURNEMENT

Result and discussion

Voltage and frequency dependence of EL brightness

The EL brightness as a function of applied voltage has been measured at constant field frequency for all the samples. The log of brightness (B) has been plotted on arbitrary scale against $V^{\frac{-1}{2}}$ are shown in fig(1- 4*). The plot is found to be a straight line obeying the relation [6,7,8].

$$B=Bo \exp (-\frac{b}{\sqrt{V}}) \qquad (1)$$

Where B_0 and b are constant.

In the case of phosphor ZnSe:Pb, ZnSe:Sm, ZnSe: (Pb,Sm) the plot is found to consist of two straight lines inclined to each other and obeying relation (1) above and below the

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bending points. These aspects may be due to the presence of different luminescence centres with different activation energies. The derivation of equation (1) is based on the assumption of Mott-schottky type depletion barrier inside the phosphors where the field E varies as the square root of the voltage. These observations show the mechanism of electroluminescence in the phosphors studied in the acceleration collision type [9,10].

The variation of EL brightness with frequency of the applied field at a constant voltage for the phosphors ZnSe:Pb (Pb=0.01%) at constant voltages 200 V , 400 V , 600V are shown in fig.5. The brightness increases linearly with frequency and attains saturation then decreases at higher frequencies at a fixed voltage. Such behaviour is also obtained in related phosphors [11,12]

Emission spectra

Two emission bands around 522 nm, 636 nm were observed in PL spectra of ZnSe:Pb , Pb=0.01% and 530 nm , 640 nm for Pb=0.001% in fig.6. It is found that the intensity of both peak maxima reduces on increasing the dopant concentration.

The emission band are found around 535 nm, 640 nm for ZnSe:Sm , Sm=0.1% and 530 nm ,635 nm for ZnSe:Sm Sm=0.01%.In this case it is found that the intensity of both peak maxima reduces with reducing dopant concentration (fig.7) .In ZnSe : (Pb,Sm) two peaks 544 nm , 640 nm are found for Pb=0.01% and Sm =0.1% and at concentration Pb =

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0.01% Sm= 0.01% the peaks are found at 536 nm and 638 nm (fig.8).

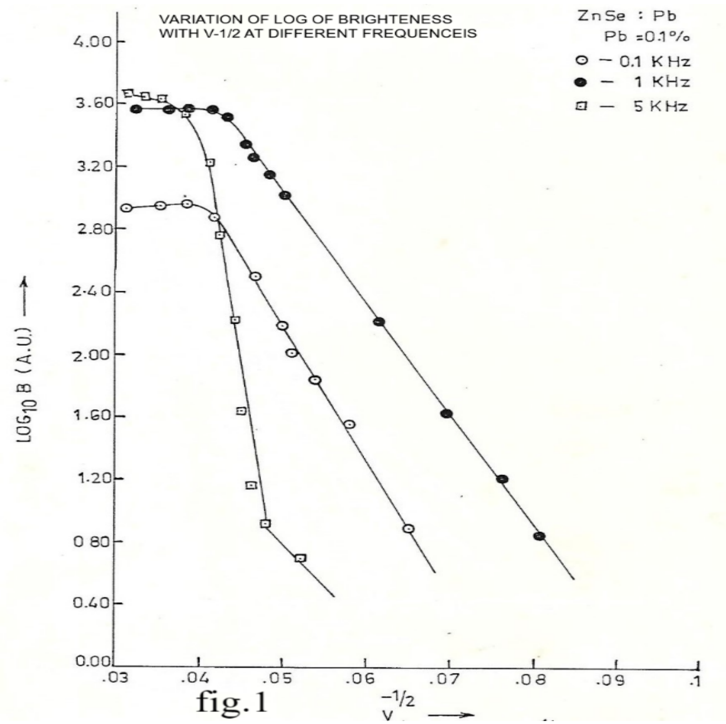

fig.1

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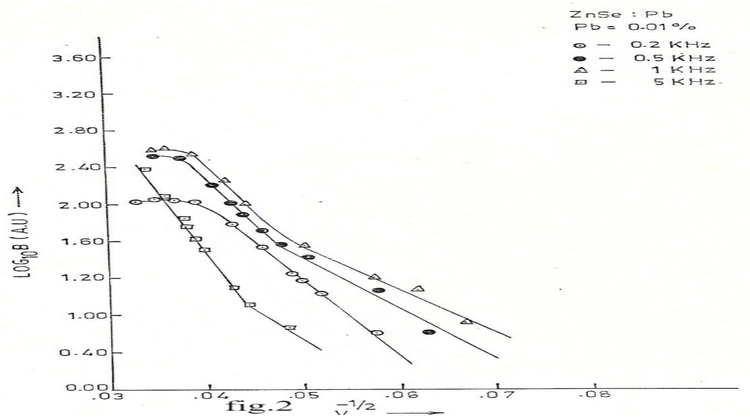

fig.2

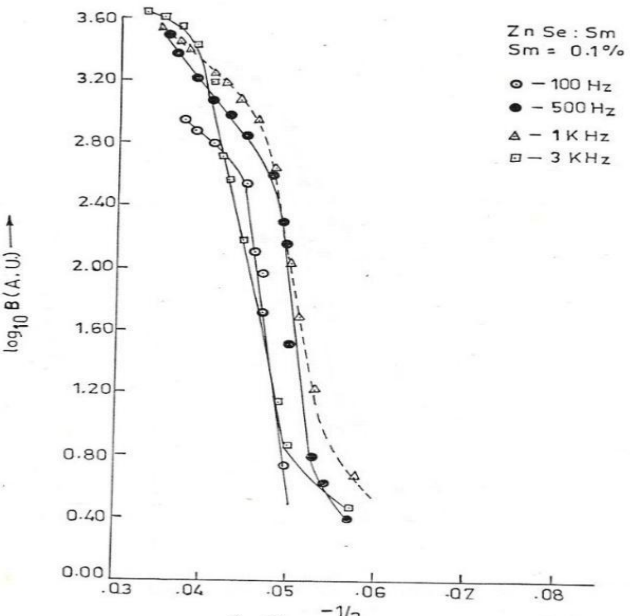

fig.3

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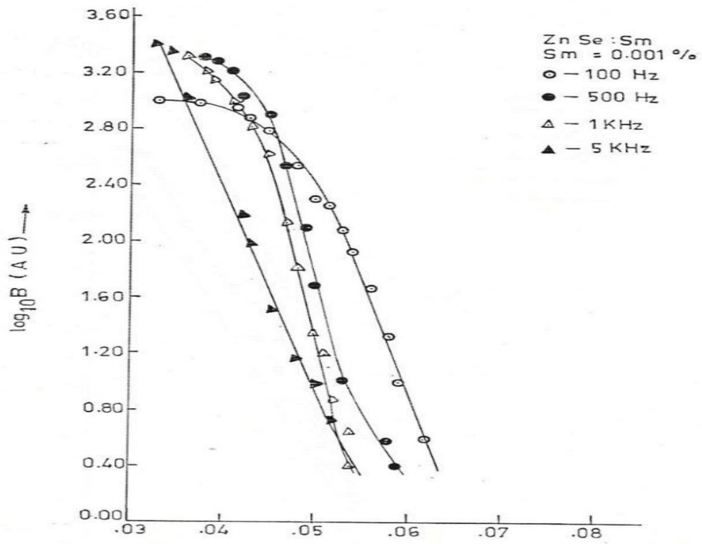

fig.4

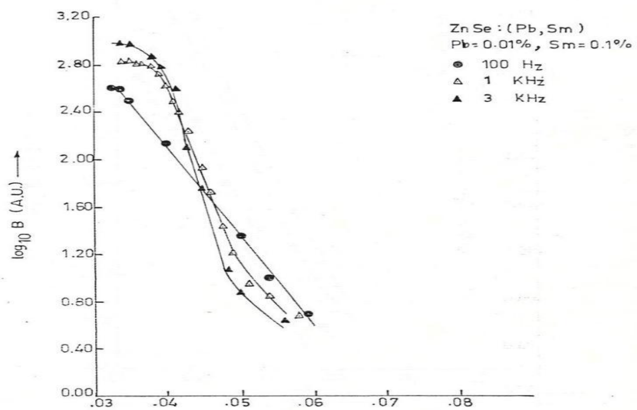

fig.4*

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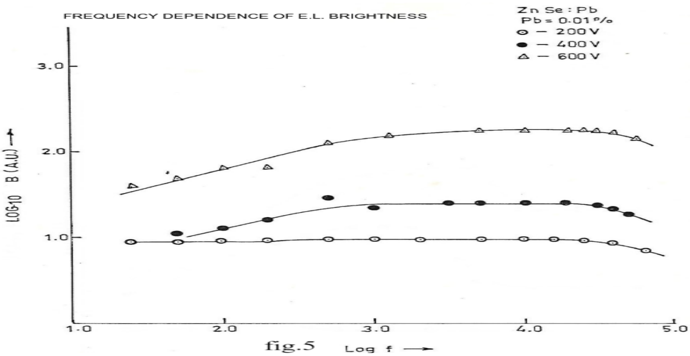

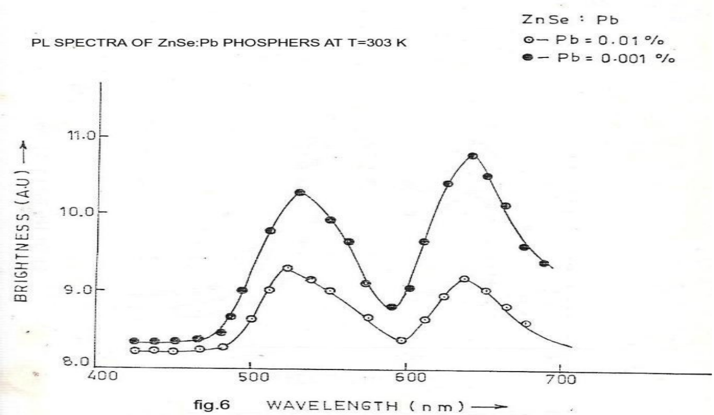

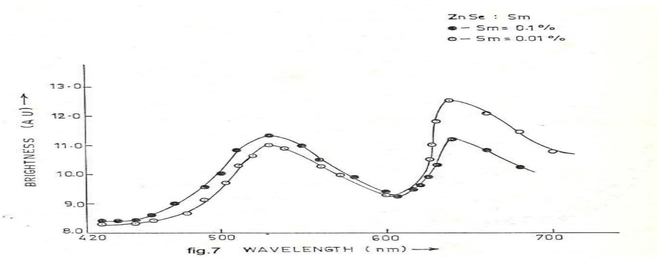

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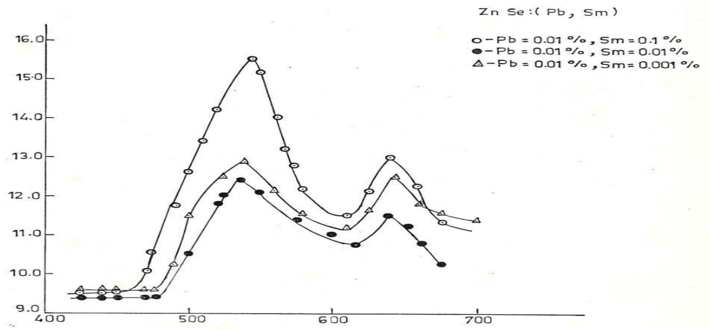

fig.8

Table 1

Characteristics Of Pl Emission Spectra Of ZnSe:Pb , ZnSe:Sm , ZnSe: (Pb,Sm) PHOSPHORS

S.NO.	Phosphor	PL Emission peak (nm)	Brightness(A.U.)
1.	ZnSe:Pb Pb=0.01%	522 636	9.3 9.2
	Pb=0.001%	530 640	10.3 10.8
2.	ZnSe:Sm Sm=0.1%	535 640	11.3 11.2
	Sm=0.01%	530 635	11.0 12.5
3.	ZnSe: (Pb,Sm) Pb=0.01% Sm=0.1%	544 640	15.5 13.0
	Pb=0.01% Sm=0.01%	536 638	12.4 11.5

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	Pb=0.01% Sm=0.001%	540 645	12.9 12.5

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