Thermal Stimulated luminescence of ZnO With Linearly Heating

Rate

By

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I hereby declare that this Masters thesis is my original work and has not been presented for a degree in any other university, and that all sources of material used for the proposal have been duly acknowledged.

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abstract

In this work, we have employed for the analysis of thermoluminescence TL glow curves of Zinc oxide ZnO materials. The continuous promotion in numerical methods has greatly helped to solve the complex Thermoluminescence TL kinetic equations which can not be solved analytically. In this thesis, the properties of the thermoluminescence glow curves of zinc oxide ZnO has been employed theoretically in view of first order kinetics. As activation energy increase the glow curve shifts to higher temperatures with a decrease in the height . For higher E values or deeper traps more energy or higher temperature is needed to release the charge carriers. Therefore, Similar changes can be noticed as the parameter S is varied but now in the opposite way: As frequency factor S increases the peak shifts to lower temperatures with an increase of the height and a decrease in width. A trapping center with a high frequency factor needs less energy or it needs lower temperature to free a charge carrier.

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Introduction

1.1 Background of the study

In order to understand how thermoluminescence (TL) can be used to study luminescent materials, a theoretical background of the phenomenon is important[1]. The basic effect leading to the production of TL is the trapping of charge carriers, electrons and holes, produced during exposure to an external source at defect sites in the material. Defect sites can be divided into two categories: (1) those inherently present in the material; and (2) those produced by external means, such as deliberately doping the sample with impurities[2]. A well-known example of the first category is a negative ion vacancy. Such a vacancy can trap an electron and is then called an F center. An example of the second category is a lattice vacancy caused by a higher valence impurity ion at the position of a lattice ion.

A trivalent cation impurity in a divalent lattice, for example, would induce the formation of a cation vacancy in the lattice to maintain charge neutrality. Cationic vacancies are potential sites for trapping holes. There are many other types of defects that can act as electron or hole trapping centers[3]. Revealing the nature of those defects is part of the research of luminescent materials. Heating of the mate-

rial causes the release of the trapped charge carriers and the recombination of electrons and holes at a luminescent center. The release of some of the stored energy excites the center and relaxation may lead to the emission of light. The nature of the luminescent center can be revealed by measuring the emission spectrum which is in many cases characteristic for a specific element. We note that not every recombination event leads to luminescence. If, for example, there is not enough energy available to excite the center, the recombination will be non-radiative.

The process leading to recombination includes, in many cases, the transition of charge carriers through the conduction or valence band, but localized transitions may also take place[4]. The theory of thermally stimulated luminescence (TSL) consists of solving the relevant sets of coupled differential equations, describing the charge transfer. In the following, we discuss the simplest model. This model shows all the characteristics of the thermally stimulated luminescence (TSL) phenomenon[5].

1.2 The Definition of Luminescence and Thermoluminescence

The term luminescence implies luminous emission which is not purely thermal in origin i.e, luminescence is "cold light", light from other sources of energy, which takes place at normal and lower temperature based up on the means of excitation there are various types of luminescence.

From the type of luminescence Thermoluminescence is one of them for this case it have also definition. The term "thermo luminescence" (TL) consists of two words: thermo, meaning heat and luminescence, meaning emission of light[6]. These

words may appear to mean that the emission of luminescence is caused by heat. This however is not totally true, since heat has only a secondary role in this case. When heat is the primary cause, the emission is called incandescence, for example, the light coming from a hot filament lamp or a burning charcoal[7].

The primary agents for the induction of TL in a material are the ionizing radiations, namely the X-rays, or radiations from radioactive elements to which the sample is pre-exposed. In some materials, ultraviolet light also may excite TL[8]. When the sample is subsequently warmed up, luminescent light is emitted. The act of warming up stimulates the release of the stored energy in the sample due to pre-exposure to the ionizing radiations. The release of this stored energy produces the luminescence[9].

There fore, some authors have appropriately used an expanded expression for this emission calling it radiation induced thermally stimulated luminescence. Some others have abbreviated it to radio thermoluminescence to signify that the TL is induced by the radiations. Some authors call it thermally stimulated luminescence(TSL). Pres-ently however, most workers of this field have become accustomed to the abbreviated term TL. Incandescence appears in the visible wavelengths only when the temperature of the heated object goes above about 500^0C when a faint red glow begins to appear. As the temperature is raised further, the object becomes brighter and brighter. The temperature of the tungsten filament in a light bulb may go up to about 2,500^{0}C[10].

In contrast, TL may appear at any temperature. It appears in the form of a transient glow, when the sample is heated for the first time after exposure to the ionizing

radiations. Repeat heating does not produce any emission, unless the sample is irradiated by Ionizing radiation once again. If the sample is irradiated in ice or at liquid nitrogen or liquid helium temperature, the emission of glow may start at any temperature above the temperature of irradiation[6]. Bhasin [1] has made an instrument to measure a glow curve from LNT to about 350^0C. Using this instrument one may see in Litium floride doped with magnisium LiF:Mg, Ti, a strong glow appearing at about 128^0C . The emission of glow may appear in one or more flashes when the sample temperature is raised slowly. The record of light intensity (measured by an instrument such as photomultiplier tube) against time or against temperature is called a glow curve. Usually, however, the intensity is recorded against the temperature. The individual flashes of light in the glow curve record are called glow peaks. In some samples, for example in blue-green variety of fluorite mineral the flashes (glow peaks) can be visually seen coming one after another if the sample is heated in a dark room after a high dose of X or gamma radiations.

In some samples even the color of light differs from one flash to other. The color or the spectral property of the glow peak tells about the TL light emitter species, which may be present as an impurity in the bulk sample[10,11]. Since ZnO it is a unique physical and chemical properties such as high electro chemical stability, high electro chemical coupling coefficient broad rage of radiation absorption, photostability and group II-VI compound semiconductor. Also have a wide band gap material. It has band gap energy of 0.54 eV and exciton binding energy of 60 meV at room temperature[12]. Because of large binding energy of excitons it is expected that ZnO can sustain excitonic emission at higher temperature. ZnO nano-sheets

can sustain excitonic emission up to 870K [13].

1.3   Statement of the problem

Many researches have been done on the nanoparticles of materials and dosimeter of thermoluminescence materials. They have been series of variation in(TSL). Thermally stimulated luminescence of ZnO with linearly heating rate plays significant role in the area of the application of this material (ZnO). In addition to this the knowledge of the thermoluminescence properties of ZnO is very important to distinguish it from other materials. To the best of our knowledge this problem has not be studied in other researcher. Therefore, the major concern of this research is to compare the experimental value of thermally stimulated luminescence of ZnO with linearly heating rate with theoretical values.

1.4   Research questions

✓ What is the effect of Activation energy on Thermoluminescence (TL) glow curves of ZnO ?

✓ How can we generate the thermoluminescence (TL) glow curves of ZnO theoretically using various heating rates ?

✓ What is the effect of Frequency Factor on Thermoluminescence (TL) glow curves of ZnO ?

✓ What are the variation of concentration of electrons in the trap of ZnO ?

1.5 Objectives

1.5.1 General Objective

The general objective of this research is to study the thermally stimulated luminescence of znO with linear heating rate .

1.5.2 Specific Objective

The specific objectives of this study are:

✓ To examine the effects of Activation energy on Thermoluminescence (TL) glow curves of ZnO.

✓ To generate the thermo luminescence (TL) glow curves of ZnO theoretically using various heating rates.

✓ To examine the effects of Frequency Factor on Thermoluminescence (TL) glow curves of ZnO.

✓ To examine the variation of concentration of electrons in the trap of ZnO.

1.6 Significance of the Study

This study may be used as a reference for the scientific community to know about thermally stimulated luminescence of znO with linearly heating rate. Also helps as starting for other researchers.

1.7 Scope of the Study

The research is intended to investigate the thermally stimulated luminescence of ZnO with linear heating rate, activation energy, frequency factor and concentration of electron by using the experimental value to generate the theoretical value of TL glow curves of ZnO.

1.8 Limitation of the Study

Due to time constraint, the scope of this study was limited only to determine the linear and theoretical of thermally stimulated luminescence of ZnO with linear heating rates, activation energy, frequency factor and concentration of electron glow curves of ZnO as theoretical.

1.9 Thesis Outline

This study was organized as follows: In chapter 1, we have discussed some background concepts of Luminescence and Thermoluminescence including the statement of the problem, research question, objectives and significance of the study, scope of the study and limitation of the study. In chapter 2, we review the theoretical concept of thermoluminescence, type of thermoluminescence, the kinetic parameter, order of kinetics, model of TSL and application of thermoluminescence. In chapter 3,result and desiccation of the glow curve of thermally stimulated luminescence of ZnO and finally in chapter 4, we draw some conclusions.

2

Review of Related Literature

2.1 Introduction

In this unit a literature review of thermally stimulated luminescence of Zno with linearly heating rate will be present in detail. In recent decades, the search for new luminescent materials has been intensified due to applications in many different fields, like light emitting diode (LED) based lighting systems, persistent luminescence phosphors, storage phosphors, scintillators, and up and down conversion materials for solar cells[14]. Progress in the identification of new luminescent materials requires insight into the underlying mechanisms and the role of the defects in those materials. Achieving this insight requires instrumentation and dedicated experimental methods. Thermally stimulated luminescence (TSL) is light produced by heating a solid to a temperature below that of incandescence[15]. The light is only observed after exposure of the solid to radiation, i.e., absorption of energy from an external source[16].

The heat only works as a trigger. The main application of TSL is in radiation dosimetry since it has been shown that for some materials, the emitted light is proportional to the absorbed dose to which the material has been exposed. This is the

case not only in personal dosimetry, but also for environmental, clinical, and high dose dosimetry. Another important application is using TSL as a dating method complementary to radiocarbon. TSL is able to date inorganic materials, mainly ceramics, while radiocarbon is limited to organic materials[1,]. TSL dating has also turned out to be useful in fields different from archaeology and historical architecture,in particular, the dating of sediments. However, it was recognized in the fifties of the last century that TSL can not only be used for dosimetry and dating, but also for other purposes like measuring the efficiency of surface catalysts and determining impurities in rocks .

Thermo luminescence is extremely sensitive to defects in the material under investigation and can therefore also be used to study these defects. As the instrumentation developed further, it became clear that TSL could also be used in material science . Recently, Mihkovand Nikl reviewed spectroscopic methods, including TSL,to probe the excited state of emission centers. However, a review especially dedicated to the role of thermo luminescence as a research tool for the investigation of luminescent materials is lacking. This review briefly recalls the theoretical background and instrumentation and then uses a range of examples to show how thermo luminescence studies can be effective in revealing the luminescent mechanism for a variety of research problems[17].

2.2   Type Of Luminescence

There are several varieties of luminescence, each named according to what the source of energy is, or what the trigger for the luminescence is, for example:-

1. Chemoluminescence: The emission of light by the release of energy from a chemical reaction is called chemo luminescence

2. Bioluminescence:Bioluminescence is also known "living light" and the most amazing examples of the phenomenon can be found in the deep seas. In the darkness of the oceans where sun light can not reach, several living organisms produce light as the result of chemical reactions.

3. Triboluminescence: In this accidentally discovered type of luminescence, light is generated by mechanical energy. Pulling apart, ripping, scratching, crushing, or rubbing can result in the breaking of chemical bonds in the material which triggers light emission like in suger or silicon crystals. It is also called mechanoluminescence.

4. Cathodoluminescence(CL): The light emission is a result of electrons beam excitation. Both in the case of cathode ray tube (CRT), televisions or computer screens and a scanning electron microscope (SEM), an electron gun is used for this purpose.

5. Electroluminesence(EL): Light is generated in response to an applied electric field on a certain material. The most used electroluminescent devices in daily life are certainly light emitting diodes (LEDS).

6. Photoluminescence(PL): Emission of the light is the result of the excitation by electromagnetic radiation/photons. It is ales specific term which embraces both fluorescence and phosphorescence. Photoluminescence has a very broad application area from whitening substances in washing powder to plasma screens for large scale displays. There are special type of luminescence which has a very slow decay with the emission continuing for minutes or hours. This type of luminescence is called long lasting or persistent luminescence and it is commonly used in road safety and exit marking.

7. Thermoluminescence (TL): It is also known as thermally stimulated luminescence (TSL). It is the luminescence activated thermally after initial irradiation by other means such as α, β, γ,UV or x-rays. It is not to be confused with thermal radiation: the thermal excitation only triggers the release of energy of energy, imparted to the material from an other source of excitation.

8. Radioluminescence (RL): It is a phenomenon by which light is produced I n a material by bombardment with ionizing radiation such as beta particles, x-rays or gamma rays.

9. Sonoluminescence(SL): It is the phenomenon by which light is produced due to the excitation by ultrasonic waves.

2.3 Expressions for Evaluating the Kinetic Parameters

The concentration of trapped holes in the recombination center(in m^-3. The initial concentration of filled traps at time t = 0 is denoted by n_0). In a typical thermolumi-
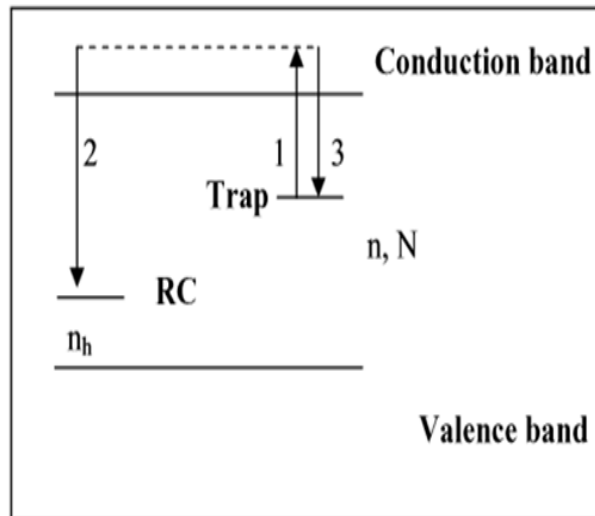
Figure 2.1: The simple two-level model for the thermoluminescence process

nescence experiment the sample is heated with a linear heating rate $\beta = dT/dt$ from room temperature up to a high temperature usually around 500_C^0. As the temperature of the sample is increased, the trapped electrons in T are thermally released into the conduction band, as shown by the arrow for transition in Figure 2.1. These conduction band electrons can either recombine with holes in the recombination center RC (transition 2), or they can be ret rapped into the electron trap T (transition 3), as shown in Figure 2.1. The intensity of the emitted light is equal to the rate of recombination of holes and electrons in the recombination center, and is given by

$$I(t) = -dn_h/dt \tag{2.1}$$

the increase in sample temperature(T), the simultaneous emission of light I(t), and the corresponding decrease in the Concentration n_h of trapped holes

2.4 Order of kinetics

Expressions for First-, Second-, and General-Order TL Kinetics is the equations governing the thermoluminescence processes have been given by Randall-Wilkins [1], Garlick-Gibson [2] and May-Partridge [3] for first, second, and general orders, respectively:

$$I(t) = -\frac{dn}{dt} = nse^{-\frac{E}{KT}} \tag{2.2}$$

$$I(t) = -\frac{dn}{dt} = \frac{n^2}{N}se^{-\frac{E}{KT}} \tag{2.3}$$

$$I(t) = -\frac{dn}{dt} = n^b s' e^{-\frac{E}{KT}} \tag{2.4}$$

where E = the activation energy or trapdepth (eV), k=Boltzmann's constant (eV K^{-1}) t= time (s), T=the absolute temperature (K), I= Intensity of glow (emission intensity), n = instantaneous concentrations of trapped electrons (m^{-3}), S = pre-exp frequency factor (1/sec). In a typical experimental situation a linear heating rate β is used to heat the sample, resulting in the temperature varying as T=To+βt,where β = linear heating rate (Ks^{-1})

2.5 Simple Model and Characteristics of Thermally stimulated luminescence (TSL)

The simplest model to explain TL is the One Trapping Centre One Recombination (OTOR) model. Absorption of radiant energy with energy greater than the band gap results in the ionization of valence electrons, producing energetic electrons

and holes which will, after thermalization, produce free electrons in the conduction band and free holes in the valence band. A certain percentage of the freed charge carriers will be trapped: the electrons at Tr and the holes at R (transitions b). There is a certain probability that the charge carriers escape from these traps due to thermal stimulation. The probability per unit time of release of an electron from the trap, p, is assumed to be described by the Arrhenius equation (2.5):

$$p = S exp(^{-}\frac{E}{KT})$$
(2.5)

The pre-exponential factors is called the frequency factor or attempt-to-escape factor. In the simple model, the factors is considered as a constant (not temperature dependent) with a value in the order of the lattice vibration frequency,namely10^{12}-$10^{14}s^{-1}$. E is called the trap depth or activation energy, which is the energy needed to release an electron from the trap into the conduction band .The other symbols have their usual meaning;k= Boltzmann's constant =8.617x10^{5}ev/k,and T is the absolute temperature.

The Quantities E and s are called the trap parameters. Their values determine whether the electron will escape at a certain temperature T. If the traps depth $E \gg$KT$_0$,with T$_0$ representing the temperature at irradiation, then any electron that becomes trapped will remain so for a long period of time, so that even after exposure to the radiation, there will exist a substantial population of trapped electrons. Furthermore, because the free electrons and holes are created and annihilated in pairs, there must be an equal population of trapped holes at level R. Because the normal equilibrium Fermi level E$_f$ is situated below level Tr and above level R, these

populations of trapped electrons and holes represent a non-equilibrium state.The return to equilibrium can be speeded up by raising the temperature of the TL material above T_0. This will increase the probability of detrapping and the trapped electrons will now be released from the trap into the conduction band. The charge carrier migrates through the conduction band of the material until it undergoes recombination at recombination center R.

In the simple model following Randall and Wilkins [11], this recombination center is a luminescent center where the recombination of the electron and hole leaves the center in one of its higher excited states. Return to the ground state is coupled with the emission of light quanta, i.e, thermoluminescence. However, it should be realized that not every de-excitation leads to the emission of light. The non-radiative transitions depend on the temperature. Sometimes, at higher temperatures, the TL is completely thermally quenched. In the simple model, it is assumed that there is no quenching and no retrapping, i.e., all electrons released into the conduction band give rise to recombination under the emission of light.Let us denote n(m^{-3})as the concentration of trapped electrons and m(m^{-3})as the concentration of holes trapped at R.

Then, the TL intensity I(t), in photons per unit volume and per unit time $(m^{-3}s^{-1})$at any time t during heating is proportional to the rate of recombination of holes and electrons at R. This rate of recombination is, under the mentioned assumptions, equal to the rate of thermal excitation of electrons from trap (Tr) into the conduction band:

$$I(t) = -\frac{dm}{dt} = -\frac{dn}{dt} = np = ns exp^{-\frac{E}{KT}} \tag{2.6}$$

This differential equation above describes the charge transport in the lattice as a first-order process. Usually, TL is observed as the temperature T is raised as a linear function of time according to:

T(t) =T_0+βt

With β(K s^{-1}) representing a constant heating rate and T_0 indicating the temperature at time t= 0.
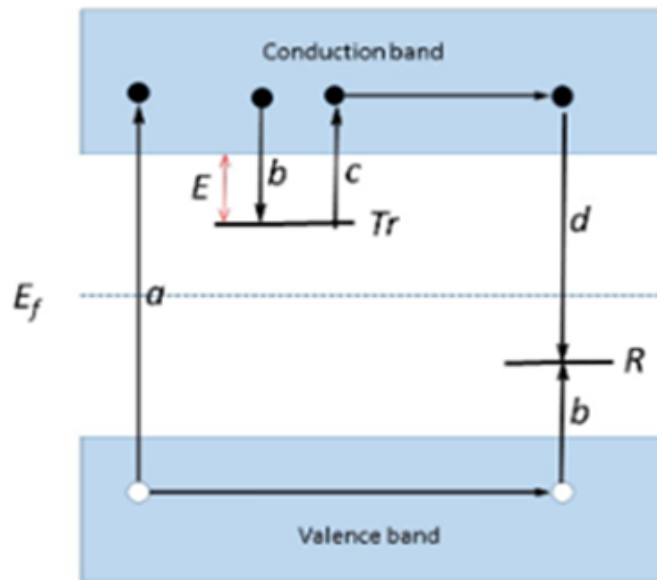
Figure 2.2: A simplified model of the thermoluminescence mechanism: During the excitation stage (a) electrons and holes are produced which are trapped (b) in trapping, T_r,and Recombination centers,R. During the heating stage (c) electrons are released to the conduction band and move through the Conduction band until they encounter a hole in a recombination center (d). The recombination energy will excite the center and relaxation of the excited center will produce the luminescence.

2.6   Applications of Thermo luminescence

Thermoluminescence is used in various fields by different scientist all over the worlds. like:- in Archaeology, Geology, Biomedical, Engineering, Chemistry, Physics and in industural Application for quality control, Research and developments[23]. The thermo luminescent materials used in the industry have three major areas; radiation dosimetry, age Determining and geology. The radiation dosimetry measures the dose that is absorbed by the sample that is exposed to irradiation. Radiation dosimetry has three subgroups; personnel dosimetry, medical dosimetry And environmental dosimetry.Personnel dosimetry is used in areas where the personnel are exposed to radiation; nuclear reactors, radiotherapy wings in hospitals and nuclear powered submarines or such. Therefore, the purpose of using personnel dosimetry is to keep track of the radiation exposure level of the individual to avoid averts radiation based effects.

The safe limits are determined by organizations such as International Commission on Radiological Protection (IRCP). Besides, from the constant radiation exposure, there are accidental or incidental radiation exposures, which are also measured by personnel dosimetry. Personnel dosimetry has three sub categories; extremity dosimetry, whole-body dosimetry and tissue dosimetry. The first one focuses on body parts that are exposed to radiation such as hands, arms or feet while the whole - body focuses on the tissue below the surface of the body or the critical organs. It measures the dose absorbed in these parts of the body by dealing with gamma

and X-rays (greater than 15 keV) and neutrons which are penetrating rays. Tissue dosimetry, which is also called skin dose, measures the dose absorbed by skin. However rather than dealing with penetrating radiation, it focuses on non-penetrating radiation such as beta particles or<15 KeV X-rays.

In order for these measurements to be done, a thermo luminescence dosimetry(TLD) material that is equivalent to the human tissue is needed. The TLD material should absorb the same dose or amount of radiation as the human tissue would do in the same area within the same radiation levels. Medical dosimetry intends to measure the effects of a TLD that is placed into the appropriate places within human body. By doing so, before exposing the patient, to ionizing radiations for treatment procedures or diagnosis, measurements can be made upon these TLD. From the data obtained, possible additional treatments or dose control can be implemented. It is impossible to do so by means of other than radiation dosimeter. The major variables that determine patient doses include imaging modality, technical factors and in the case of fluoroscopy, beam time [21]. In addition to these factors, the size of the patient is also a determining factor. Medical dosimetry has two categories; diagnostic radiology and radiotherapy. The radiation used here may be X-rays (near 10 KeV level), gamma rays, beta particles, protons and other heavy particles and neutrons [24].

Again, the TLD material needs to be tissue equivalent and highly sensitive. The latter is needed for measurements done in laboratory conditions that require the possible smallest size of TLD material. Other than these properties, the TLD should not be toxic. Recommended diagnostic reference levels for medical imaging modal-

ities have been publish hed by the ICRP.

Environmental dosimetry deals with the radiation present in the environment due to humankind. Due to applications like nuclear power stations, waste disposals, usage or processing of nuclear fuels and disastrous nuclear power plant malfunctions introduce high levels of radiation into the environment. Therefore, it becomes essential to monitor the radiation released to the environment continuously.exposed to radioactivity and will absorb a certain amount of it, which will be measured to get the archeological age of the pottery.

Thermoluminescence is now an established way of age determination. Minerals tend to give off different glow curves according to their location of extraction. Since thermoluminescence is a fine way of radiation trace detection, this enables to identify the source of these minerals by using thermoluminescence in geology. Another aspect of geology that uses thermoluminescence is in examining meteorites and materials originating from the moon. It is possible to tell the distance of meteorite to the sun while it was traveling in the space as well as how long the meteorite was on earth. Thermoluinescent properties of materials enable them to be used in dosimeters, which are used in measuring doses of radiation. Since characteristics of materials differ from each other, different materials with different thermoluminescent properties are preferred for different purposes.

2.7 Thermoluminescence Equations for first order kinetics

The assumption is that there is a strong tendency to recombination and that electrons, which are released thermally from the traps and excited in to the conduction

band recombine quickly with trapped holes.

No re-trapping is allowed.

During Thermoluminescence(TL) the temperature increases linearly with time.

Rate equation.

$$\frac{dn}{dt} = -sexp(-\frac{E}{K_\beta T})n + A(N-n)n_c \tag{2.7}$$

Where n is the concentration of electrons in traps, n_c is the concentration of electrons in conduction band, N is the total concentration of available electron traps (of depth E below the conduction band), A is the transition coefficient of electrons in the conduction band becoming trapped S is the trapping parameter. But since re-trapping is negligible,

$A(N-n)n_c = 0$

Hence,

$$\frac{dn}{dt} = -Sexp(-\frac{E}{K_\beta T})n \tag{2.8}$$

$$T = T_0 + (\beta)t \tag{2.9}$$

Here T_0 is the initial temperature at time $t = 0$ and β is the heating rate.

Solving for n from equation (2.7) and using (2.8) gives,

$$n(T) = n_o[exp(-\frac{S}{\beta}) \int_{T_o}^{T} exp(-\frac{E}{K_\beta T}dT))] \tag{2.10}$$

But the thermoluminescence intensity $I(T) = -\frac{dn}{dt}$ using equations (2.6) and (2.9) gives the following first order kinetics thermoluminescence behavior.

$$I(T) = n_0 S exp(\frac{-E}{K_\beta T}) exp[-(\frac{S}{\beta}) \int_{T_0}^{T} exp(\frac{-E}{K_\beta T} dT)] \qquad (2.11)$$

The above equation defines temperature dependent thermoluminescence behavior for first order kinetics.

3

Materials and Methodology

3.1 Materials

This study has been carried out by using the following materials. These are:- The journals, hand books, thesis and dissertation.

3.2 Graphical Analysis

Analytically solved thermoluminescence equation and results will be interpreted graphically using mathematica soft ware.

4

Results and Discussion

4.1 The effect of Activation Energy on Thermoluminescence (TL)Glow Curves of ZnO

It is the energy(E), expressed in (eV), assigned to a level With in the forbidden band gap between the conduction band (CB) and the valence band (VB) of a crystal. This energy is also called trap depth. The properties of activation energy of ZnO can be given in the graphs blow.
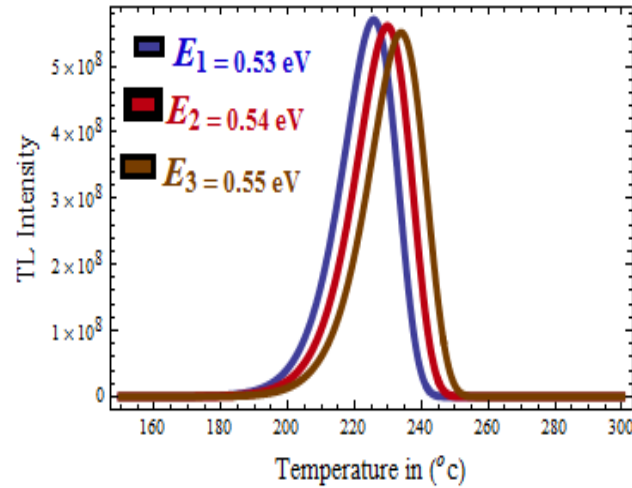
Figure 4.1: Thermoluminescence(TL) glow curve peaks depending on different activation energy E and constant dose of electron, frequency factor and linearly heating rate by using the Randall- Wilkins Equation (4.5)

Figure 4.1 shows the graph of glow curve peak characteristics, namely the peak temperature T_m and the peak shape remain unchanged when the initial filled concentration (n_0) of the traps is changed. This means that the peak characteristics are independent of radiation dose given to the sample. However, the intensity (the area as well as the height of the peak) increases in direct proportion to (n_0) for given (E),(S) and (β). This means that the intensity is directly proportional to dose given to a sample, assuming that the trap filling is directly proportional to the dose. These characteristics are unique to First order (FO) kinetics and are of prime importance in the application of TL in radiation dosimetry as well as in kinetics analysis of the

glow curves.

Activation energy can be increase the intensity of the thermoluminescence can be decrease and for trapping electron more energy produce on the high activation energy and less energy is produce on the less activation energy. Because of this the glow curve of activation energy is decrease from less activation energy to high activation energy. Also the glow curve can be shift from minimum to the maximum of the temperature.

4.2 Effect of Linear Heating Rate on Thermoluminescence (TL)Glow Curves of ZnO

Heating rate (β) is an important parameter for the determination of the various kinetic parameters of TL glow curves. In literature it has been reported that the glow peak height decreases [23] or increases [24-25] with increasing heating rate. When the linear heating rate β changes, the temperature T_M of the maximum TL intensity of the peak also changes: faster heating rates produce a shift in temperature toward higher values of T_m. Depending on the given data the theoretical thermoluminescence(TL) glow curves measured with different heating rates ($\beta_1 = 1$, $\beta_2 = 2$, $\beta_3 = 3$, and $\beta_4 = 4K\ s^{-1}$). It is known that this TL peak follows first-order kinetics.

On the other hands as shown in fig.4.2 at constant concentration of electron (n_0),activation energy (E) and frequency factor (S) . A glow Curve peak maximum with different values i.e $\beta_1 = 1$, $\beta_2 = 2$, $\beta_3 = 3$ and $\beta_4 = 4$ K s^{-1} T_m are difficted β. when heating rate(β) increases, the glow peaks shift to higher temperatures, and the in-

tensity of the Thermoluminescence (TL) peak changes. This all effect is shown in Figure 4.2. The linear heating rate can be increase the intensity of thermolumi-
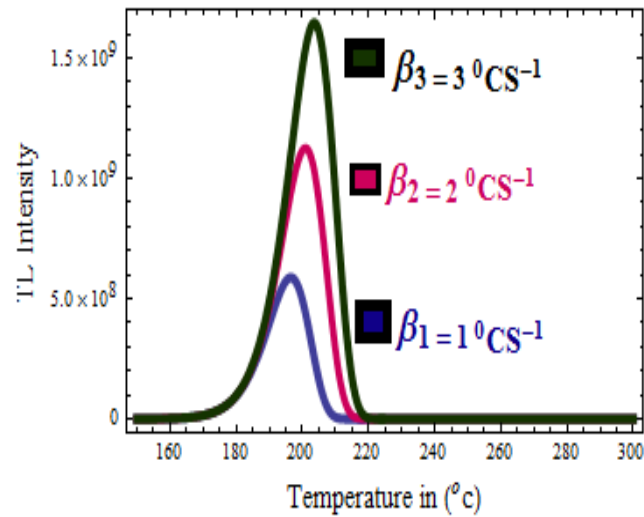

Figure 4.2: TL glow peaks calculated with the Randall-Wilkins Equation (3.5) for n_0 = 10^{11} m^{-3}; $S = 10^{12}$ s^{-1}, $E = 0.54$ eV and different values of the heating rate β.

nescence also increase and for trapping electron more energy produce on the less linear heating rate and less energy is produce on the high linear heating rate. The glow curve can be shifted from minimum temperature to maximum temperature. Because of this the glow curve of linear heating rate is increase from less linear heating rate to high linear heating rate.

4.3 The Effect of Frequency Factor on Thermoluminescence (TL) Glow Curves of ZnO

As discussed above, the un trapping of an electron from a trap of depth (E) under thermal stimulation involves two steps: first, the electron is elevated to an energy level (E) above the ground state of the trap by the thermal agitation. The fraction of the trapped electron population that can achieve energy nearly equal to the trap depth (E) above the ground state of the trap is given by the Boltzmann function, $\exp\left(-E\diagup_{\beta}T\right)$
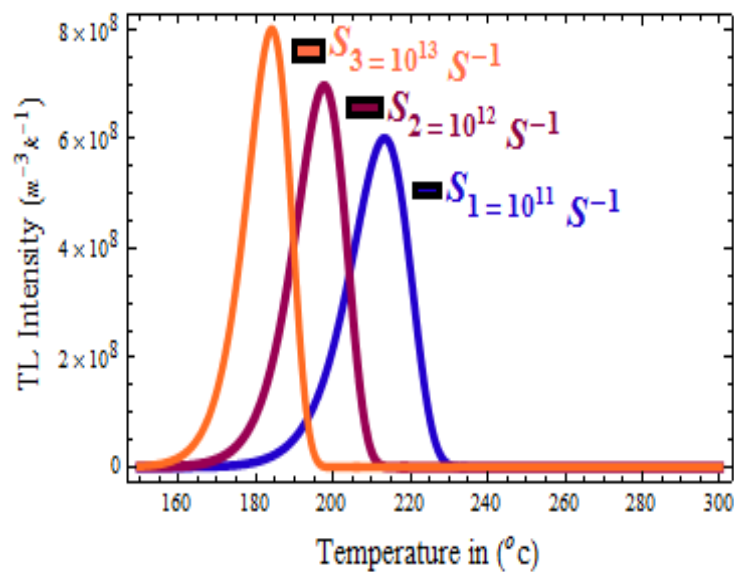

Figure 4.3: Thermolimunescence (TL) glow curve peak maximum with change in S a glow curves for S. $S_1 = 10^{12}$, $S_2 = 10^{12.1}$, and $S_3 = 10^{12.2}$ S^{-1} T_m versus S the frequency factor increases, the glow peaks shift to lowest temperatures

Figure 4.3 shows the graph of frequency factor at constant concentration of elec-

tron *(n_0)*,activation energy *(E)* and linear heating rate(β). A glow curve peak increase from S_1 to(S_3). $S_1=10^{11}$, $S_2= 10^{12}$,and $S_3= 10^{13}$ S^{-1} T$_m$ versus S the frequency factor increases, the glow peaks shift from high temperatures to less temperature. The frequency factor can be increase the intensity of thermoluminescence also increase and for trapping electron more energy produce on the less frequency factor and less energy is produce on the high frequency factor.

The glow curve shift from maximum temperature to minimum temperature the peak can be increase, because of this the glow curve can be increase from less frequency factor to high frequency factor. The same to that the glow curve decrease from high frequency factor to less frequency factor. The intensity of thermoluminescence also decrease from high frequency factor to less frequency factor.

4.4   The variation of concentration of electron (n_0)in trap

Thermoluminescence(TL) glow peaks calculated with the equation 2.30 as $E=0.54eV$ and different values of the concentration of electron (n_0).
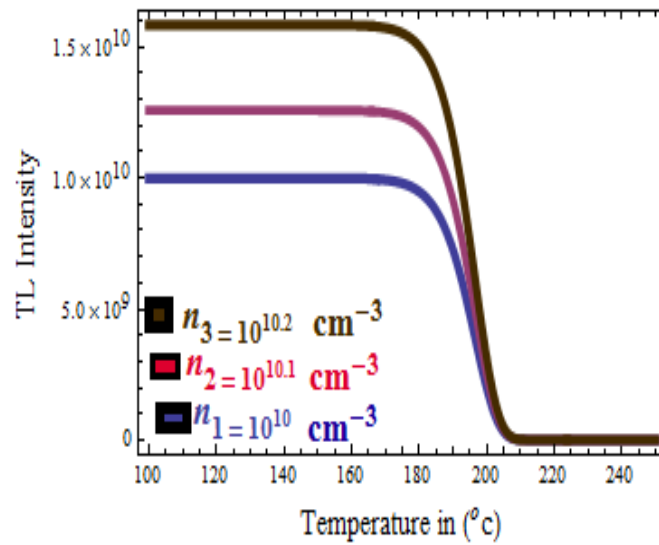
Figure 4.4: Thermoluminescence(TL) glow peaks of defferent concentration of electron calculated with the equation (2.30) as at constant activation energy (E),frequency factor (S) and linearly heating rate(β)

Figure 4.4 shows the graph of concentration of electron at constant frequency factor (S),activation energy (E) and linear heating rate(β) a glow curve peak maximum with change in concentration of electron n_0 a glow curves for n_0. $n_0=10^{10}$, $10^{10.1}$ and $10^{10.2}$ cm^{-3} T_m versus to the concentration of electron increases, the glow peaks shift to highest temperatures or temperature is increases , and the height of the thermoluminescence (TL) peak changes to the high temperature(increase) and intensity of Thermoluminescence (TL) also increase.

In general concentration of electron in trap states can be increase the intensity of thermoluminescence also increase and for trapping electron more energy produce on the less concentration of electron/dose and less energy is produce on the high

concentration of electron/dose. The glow curve can be shift from minimum temperature to maximum temperature. Because of this the glow curve increase with increasing concentration of electron .

5

Conclusion

In this study, thermal stimulated luminesence(TSL) of ZnO with linearly heating rate with the help of first order kinetics were studied. ZnO it is a unique physical and chemical properties such as high electro chemical stability, high electro chemical coupling coefficient broad rage of radiation absorption, photostability and group II-VI compound semiconductor. Also have a wide band gap energy of 0.54 eV and exciton binding energy of 60 meV at room temperature. Such thermal stimulated luminescences are generated depending on it's activation energy, linearly heating rate, frequency factor and concentration of electrons were calculated using by first order kinetics.

Activation energy increases with increase temperature and a glow curves Inversely decrease. The same as to activation energy(E) the linear heating rate β changes, the glow curve height decreases or increases with increasing heating rate. The temperature corresponding to the maximum intensity of TL also changes. Important TL kinetic parameters; namely the activation energy (E) and the frequency factor (s) are calculated using variable heating rate method. The glow peaks obey first order kinetics.

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