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Characterization of Optical Properties of Pure Zinc Oxide Prepared by Sol – gel method by UV Device

تصنيف الخصائص الضوئية لأكسيد الزنك النقي المحضر بطريقة (سول جل) بإستخدام جهاز الأشعة فوق البنفسجية

A Thesis submitted in Partial Fulfillment of the Requirements for the Master Degree of Solid Physics

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الآيـــــــــــة

قال تعالى:

﴿يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ﴾

صدق الله العظيم

سورة المجادلة الآية (11)

Dedication

To my parent

To my family

To my friends

Acknowledgement

First of all I thank my god (Allah)

I would like to express my appreciation and respect to DR.MAHMOUD HAMID MAHMOUD HILLO he strives to help me succeed

My humble thanks are due to DR ABD ALSAKHE SULIMAN from him I saw unlimited patience , unsparing guidance , and unfailing trust

Abstract

Zinc Oxide Nano layers were prepared by sol gel method with three different thickness that’s (5, 12, 36.8) nm, which deposited by spin coating device, then the UV technique was used to determine and evaluate the optical properties of the three samples. All the optical properties were plotted and special fitting method of origin 8.1 programs used to analyze the plots, and the results showed that all samples give a high absorbance for about 80% and low transmittance, and reflectance. The absorption coefficient found to be equal $3.76*10^3$ in the wave length of UV range, the excitation coefficient found in a direct proportional with the thickness of the samples, besides, the rest of optical properties, such as refractive index, the real and imaginary dielectric coefficient, and optical conductivity were found to in conformity with theoretical works and literature results.

Analyzes show that zinc oxide is 80% higher in absorption.

Absorption coefficient = $3.76 * 10^3$

Extinction coefficient (k) = $3.76 * 10^{-5}$

Energy gap for sample (36.8 nm) = 3.673 ev

Energy gap for sample (12.0 nm) = 3.672 ev

Energy gap for sample (05.0 nm) = 3.630 ev

المستخلص

المستخلص تم تحضير الاغشيه الرقيقه لمركب اكسيد الزنك (ZnO) بطريقه المحلول الجلاتيني بقيم (5,12,36.8) نانوميتر لثلاث عينات مختلفه , وتم ترسيب هذه العينات بواسطه جهازالرش المغزلي ,تم استخدام تقنية الاشعه فوق البنفسجيه لتحديدو ايجاد الخصائص للعينات.

تم رسم كل الخصائص الضوئيه بيانيا باستخدام برامج الاحصاء الالكتروني ومن تم تحديد الرسومات البيانيه , اشارت النتائج الي ان كل العينات الثلاث تعطي امتصاصيه عاليه تصل الي 80% و نفاذيه و انعكاسيه منخفضه , معامل امتصاص وجد ان حوالي (3.768*10^3) في مدى طيف الاشعه فوق البنفسجيه اما معامل الخمود فيتناسب طرديا مع سمك العينات و وجد ان بقيه الخصائص الضوئيه مثل معامل الانكسار و معامل العزل الكهربي الحقيقي و التخيلي و الموصليه الضوئيه تتطابق مع القيم النظريه و الدراسات السابقه.

أظهرت التحليلات أن أكسيد الزنك أعلى إمتصاص بنسبة 80% .

معامل الإمتصاص = 3.76 * 10^3

معامل الخمول = 3.76 * 10^{-5}

فجوة الطاقة للعينة (36.8 nm) = 3.673 ev

فجوة الطاقة للعينة (12.0 nm) = 3.672 ev

فجوة الطاقة للعينة (05.0 nm) = 3.630 ev

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CHAPTER ONE

INTRODUCTION

Chapter One

Introduction

1.1 Motivation

Today, when the world is surmounting on the roof of technology and electronics, mostly dominated by compatible electronic equipments and thereby creating the need for materials possessing versatile properties. After digging the pages of history for the search of such type of material a very common category of material comes out that is “semiconductor”. Since independence of India the family of semiconductors is dominated by our much known elements Germanium (Ge) and Silicon(Si). Germanium get famous due to possession of property like low melting point and lack of natural occurring germanium oxide to prevent the surface from electrical leakage where as silicon dominates the commercial market for its better fabrication technology and application to integrated circuits for different purposes. As time passes on, the rapid growing world demands speed along with technology. This need was very well fulfilled by GaAs which ease the path for the design of high speed and optoelectronic devices. GaAs which is a direct band gap semiconductor possessing higher carrier mobility and higher effective carrier velocity in comparison to Si makes it better suited for optoelectronics devices. But this do not leads to the completion of requirement for the future world, something more is required that is high temperature electronics devices. The world therefore now demands a material that should possess inherent properties like larger band gap, higher electron mobility as well as higher breakdown field strength. So on making investigation about such a material the name of compound comes out is “Zinc Oxide” which is a wide gap semiconductor material very well satisfying the above required properties,not only has this Zinc oxide possessed many versatile properties for UV electronics, spintronic devices and sensor applications. Also ZnO has been commonly used in its polycrystalline form over hundred years in a wide range of applications. This ignites many research minds all over the world and creates enthusiasm to develop proper growth and processing techniques for the synthesis of Zinc oxide. Zinc oxide is also known as "Lu-Gan-Stone" in China, Zinc oxide has been used in medical treatment for quite number ofyears in China. The research on ZnO is catching fire right from the beginning of 1950, with a number of reviews on electrical [1] and optical properties [2] like N-type conductivity, absorption spectra and electroluminescence decay parameter. The nature ofexcitonic molecule in semiconductors which was discussed by Haynes [3] aiding a key publication by Park et al concerned with excitonic emission of ZnO [4] is the very first footstep put for the growth and development of ZnO research in the mid of 1960. In 1966 the Raman Effect study of ZnO by Damen and Porto [5] leads to the identification of ZnO phonon energies. The decade of 1970 for ZnO passes away in manufacturing of simpler ZnO devices like ceramic varistors, piezoelectric transducers etc. also with a progress in the study of variety of characterization techniques such as cathode luminescence(CL), capacitance – voltage studies(CV), electrical conduction and so on [6- 9]. When the researchers got fade off continues work on characterization technique for a decade, search for different growth procedure and techniques begin. In 1980 a lot of work on high quality thin films of ZnO, metallo-organic chemical vapor deposition (MOCVD) [10], spray pyrolysis [11] and radio frequency magnetron sputtering (RF) [12] has been done extensively. Overall much of the research in 1980’s attempted to resolve the issues concerning with lack of satisfactory material for device fabrication. But finally at the end of the decade there were no significant increment in the number of papers. The twilight of stars sprinkles and a new era for research of ZnO begins actually in 1990 with a uniform growth in number of publications related to both characterization and growth techniques. In 1990’s, newer growth methods were used including pulsed laser deposition (PLD) [13] and molecular beam epitaxy (MBE) [14]. At the end of late 1990 large scale commercial ZnO comes to the picture. In the field of ZnO research the last decade was mainly concerned with optimization of different growth parameters and processing techniques. Thus currently research work related to production of high quality, reproducible P type conducting ZnO for device application is the main focus. ZnO has now become one of most studied material in the last seven years as it presents very interesting properties for optoelectronics and sensing applications, in nano range synthesis.

1.2 Nanotechnology

“The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom.” these are the words which buried the seed for nano-technology in the scientific mind of number of researchers who were attending the talk of famous physicist Richard Feynman in 1959. The word actually signifies our complete control over the matter. Nanotechnology makes us to believe that we would have the ability to create anything that we could precisely define. Eric Drexler, in the early 1980′s coined the powerful word nanotechnology. The world of nanotechnology is implanting its footprint in the present decade very rapidly. Between year 1997 and 2005, investment in nanotechnology research and development by governments around the world soared from $432 million to about $4.1 billion, and corresponding industry investment exceeded that of governments by 2005 [15-19]. By 2015, products incorporating nanotech will contribute approximately $1 trillion to the global economy. About two million workers will be employed in nanotech industries, and three times that many will have supporting jobs.

1.2.1 Properties of nonmaterial

Nanostructure materials are single phase or multiphase polycrystalline solids with a typical average size of a few nanometers (1nm = 10-9m).Basically, the range from (1-100)nm is taken as nano-range for convention as per National Nanotechnology Initiative in the US., and the size of hydrogen atom is considered as the lower limit of nano wire as upper limit is arbitrary. The grain sizes are so small; a significant volume fraction of the atoms resides in grain boundaries. Material is characterized by a large number of interfaces in which the atomic arrangements are different from those of crystal lattice [15-19]. The basic classification of nonmaterial is done based on the confinement. Bulk structures show no confinement where as nano-wells and nano wires can be obtained by 2-D and 1-D confinement respectively. The quantum realm comes to the picture when there is a 3D confinement and leads to zero dimension quantum structures that is quantum dot.

1.2.2 Processing method

The synthesis of nonmaterial can be well accomplished by two approaches, firstly, by “Bottom Up” method where small building blocks are produced and assembled into larger structures. Where the main controlling parameters are: morphology, crystalline, particle size, and, chemical composition. Examples: chemical synthesis, laser trapping, self-assembly, colloidal aggregation, etc and secondly, by “Top Down” method where large objects are modified to give smaller features. For example: film deposition and growth, nano imprint /lithography, etching technology, mechanical polishing etc. the main reason of alteration in different mechanical, thermal and other property is due to increase in surface to volume ratio.

Synthesis of nonmaterial is most commonly done based on three strategies i.e.

- Liquid- phase synthesis.
- Gas- phase synthesis.
- Vapor - phase synthesis.

1.2.3 Liquid phase synthesis

Under liquid phase synthesis the techniques used for synthesis are: • Co-precipitation.

- Sol-gel Processing.
- Micro-emulsions.
- Hydrothermal/Solvo-thermal Synthesis.
- Microwave Synthesis.
- Sono - chemical Synthesis.
- Template Synthesis.

1.2.3.1 Gas-phase synthesis

- Super saturation achieved by vaporizing material into a background gas, then cooling the gas.

1.2.3.2 Methods using solid precursors

- Inert Gas Condensation
- Pulsed Laser Ablation

1.2.3.3 Spark discharge generation

- Ion Sputtering Methods using liquid or vapor precursors
- Chemical Vapor Synthesis

- Spray Pyrolysis
- Laser Pyrolysis/ Photochemical Synthesis
- Thermal Plasma Synthesis
- Flame Synthesis
- Flame Spray Pyrolysis
- Low-Temperature Reactive Synthesis

Nanostructure of materials can have significantly different properties, depending on the chosen fabrication route. Each method offers some advantages over other techniques while suffering limitation from the others.

1.2.4Applications

The two concepts necessary for nanotechnology are self-replication and positional control. These could both come from something called a universal assembler. By following the basic principles of nanotechnology a versatile number of devices can be fabricated. A nano technological computer can be built which would have the computational power of computers a few years back, and would be smaller than anything we can see with a microscope. In all, this assembler would weigh about 1.66e-15 grams, which would make it smaller than a common bacterium. Nanotechnology, like every other field, has both a good and bad side One side of nanotechnology, is that anything that can be precisely defined can be built.[18-22] If someone is hungry, they have but to go to their replication unit, (something that would probably resemble today’s microwave in design) and order whatever it is they want. With nanotechnology, there is the possibility of what is called a ‘morph’ material, a substance made up of tiny little machines that can take on any shape[22]. A table becomes a chair when unexpected company shows up, stairs that turn into ramps for the disabled, but then again, the disabled could have artificial ‘nano limbs’, that morph into useful tools when necessary. Nanotechnology could help in creating tomorrow’s computers. A computer can be designed which have the size of smallorganisms and have the computational power of today’s personal computers. This would make it possible to fit a full computer into something the shape and size of a piece of paper, including display, voice recognition, and new features that are not available, due to lack of speed and power of today’s computers. Clothes that could change colors, toys that changes shape, self adapting surgical implants, and many other things, that would drastically improve and diversify our abilities and freedom[18-22].

1.3Objective

Scope of this project work was focused on the following steps:

1. Preparation of the ZnO nano particles by sol-gel method. Zinc acetate dehydrates and tri ethanolamine is the precursor’s materials here.
2. Study the opto-electrical properties by UV-device

1.4 Problem

The development of the structural properties of the material provide results that can be used in the continuous development and axpansion of the use of specific compound

The zinc oxide compound in one of most used compound in the field of semiconductors , which in turn is used in the field of electronic devices , the study of optical properties of zinc oxide most important problem

CHAPTER TWO

THEORETICAL BACKGROUND

CHAPTER TWO

Theoretical Background

2.1 Crystal structure of ZnO

General, Zinc oxide crystallizes in two main forms, hexagonal wurtzite and cubic zinc blended but the (B_4 type) wurtzite structure is obtained only at optimum pressure and temperature[23,28]. In an ideal wurtzite crystal, with a hexagonal close-packed lattice type, has lattice parameters, a_o= 0.32495 nm and c_o = 0.52069 nm, in the ratio of c_o / a_o =1.602, and it belongs to the space group of P63mc[23,27] and is characterized by two interconnecting sub lattices of zn2+ and o2- where each anion is surrounded by four Cations at the corners of a tetrahedron with a typical sp3 covalent bonding. Among different phases of ZnO, based on the first principle periodic Hartree-Fock linear combination of atomic orbital's theory the wurtzite is found to be the most thermodynamically stable phase[23]. Tetrahedral symmetry plays a vital role for the polarity of ZnO that arises along the hexagonal axis. Piezoelectricity and spontaneous polarization are the direct consequence of polar symmetry of ZnO along the hexagonal axis[23]. The structure of ZnO, can be described as a number of alternating planes composed of tetrahedral coordinated O2- and Zn2+ ions, stacked alternately along the C-axis (Figure.2.1.)The oppositely charged ions produce positively charged(0001)-Zn and negatively charged (0001)-O polar surfaces, resulting in a normal dipole moment and spontaneous polarization along the c-axis, as well as a divergence in surface energy [25-26].The polar faces are more stable than non polar faces. The root cause for the natural N-type nature of ZnO is due to the sensitiveness of ZnO lattice constants to the presence of structural point defects (vacancies and interstitials) and extended defects (threading/planar dislocations) that are commonly found in ZnO resulting in a non-stoichiometric compound Zn_{1+d} O with an excess zinc .These excess zinc atoms have the tendency to function as donor interstitials that give its natural N-type conductivity. In ionic form, the excess zinc exist as Zn^{+} interstitials that are mobile and they tend to occupy special interstitial sites with Miller index (⅓, ⅔, 0.875) as shown in Figure.2.2.These special sites offer passage routes for zinc interstitials to easily migrate within the ZnOwurtzite structure[36].

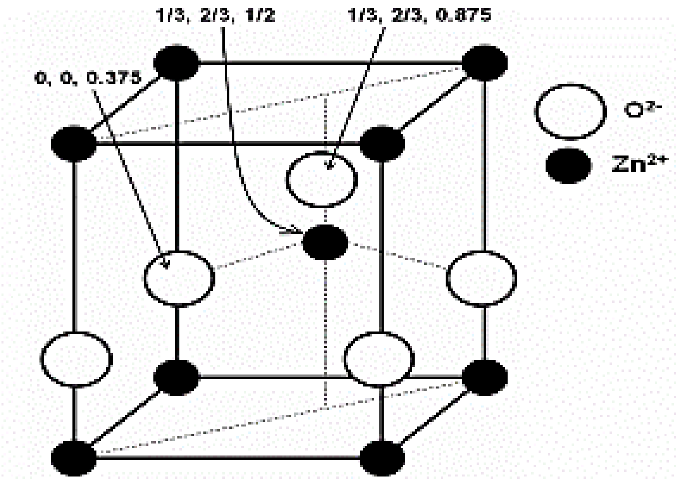

Figure (2.1) ZnO unit cell with ionic positions of zinc and oxygen atoms. Redrawnfrom [47]

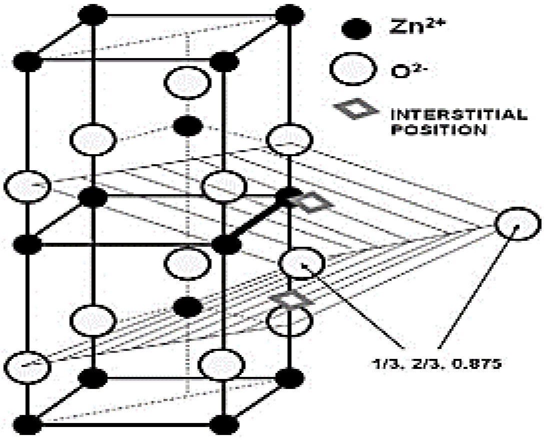

Figure (2.2) Zinc interstitial sites in the ZnOwurtzite lattice. Redrawnfrom [47]

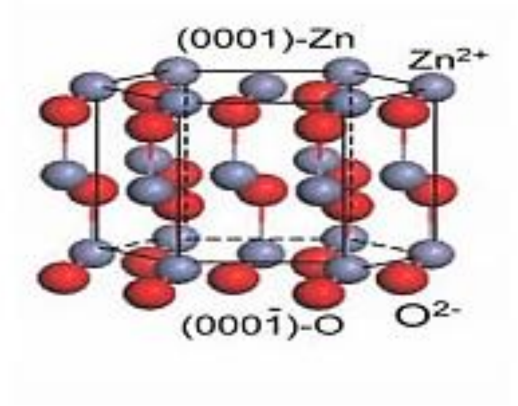

Figure (2.3) the wurtzite structure model of ZnO. The tetrahedral coordination of Zn-O is shown[28].

2.2 Optical Properties

Optical property of a material is defined as its interaction with electro-magnetic radiation in the visible.Interaction of photons with the electronic or crystal structure of a material leads to a number of phenomena.The photons may give their energy to the material (absorption); photons give their energy, but photons of identical energy are immediately emitted by the material (reflection); photons may not interact with the material structure (transmission); or during transmission photons are changes in velocity (refraction).At any instance of light interaction with a material, the total intensity of the incident light striking a surface is equal to sum of the absorbed, reflected, and transmitted intensities.Thus all 11 optical phenomena are important such as:

2.2.1 Absorption

The intensity of the net absorbed radiation is dependent on the character of the medium as well as the path length within. The intensity of transmitted or non-absorbed radiation continuously decreases with distance x that the light traverses:

$$I_T = I_o e^{-\beta x} \qquad (2.1)$$

Where is the intensity of the non-reflected incident radiation and ß the absorption Coefficient(in mm^{-1}), is characteristic of the particular material; furthermore, varies with wavelength of the incident radiation. The distance parameter x is measured from the incident surface into the material. Materials that have large values are considered highly absorptive [48].

2.2.2 Reflection

When light radiation passes from one medium into another having a different index of refraction, some of the light is scattered at the interface between the two media even if both are transparent. The reflectivity R represents the fraction of the incident light that is reflected at the interface, or

$$R = \frac{I_R}{I_o} (2.2)$$

Where I_0 and IR are the intensities of the incident and reflected beams, respectively. If the light is normal (or perpendicular) to the interface, then

$$R = (\frac{n_2 - n_1}{n_{2+} n_1})^2 (2.3)$$

Wheren_1 and n_2 are the indices of refraction of the two media. If the incident light is not normal to the interface, R will depend on the angle of incidence. When light is transmitted from a vacuum or air into a solid s, then

$$R = (\frac{n_s - 1}{n_s + 1})^2 \quad (2.4)$$

2.2.3 Absorption coefficients

Much of the information about the properties of materials is obtained when they interact with electromagnetic radiation. When a beam of light (photons) is incident on a material, the intensity is expressed by the Lambert-Beer-Bouguer law:

$$I = I_0 \exp^{-\alpha d} (2.5)$$

If this condition for absorption is met, it appears that the optical intensity of the light wave, (I), is exponentially reduced while traveling through the film. If the power that is coupled into the film is denoted by I_0, gives the transmitted intensity that leaves the film of thickness d.(α) Is called “absorption coefficient”. From (1) it follows that

$$\alpha = -\frac{1}{d}\, Lin(\frac{I}{I_o})(2\text{-}6)$$

It is clear that α must be a strong function of the energy hν of the photons. For hν<Eg (direct), no electron hole pairs can be created, the material is transparent and α is small. For hν ≥ Eg (direct), absorption should be strong. All mechanisms other than the fundamental absorption may add complications (e.g. "sub band gap absorption" through excitations), but usually are not very pronounced.

Optical transmission measurements were carried out to determine the film thickness, the wavelength dependence of the refractive index and optical absorption coefficient. The optical constants were determined from the optical transmission measurements using the method described by Swanepoel.

The transparent substrate has a thickness several orders of magnitude larger than (*d)* and has index of refraction (n) and absorption coefficient (α = 0). The index of refraction for air is taken to be n_0 =1. In the transparent region (α =0) the transmission is determined by n and s through multiple reflections. In the region of weak absorption α is small and the transmission begins to decrease. In the medium absorption region α is large and the transmission decreases mainly due to the effect of α. In the region of strong absorption the transmission decreases drastically due almost exclusively to the influence of α. If the thickness d is uniform, interference effects give rise to the spectrum.[48]

2.2.4 Transmission

The phenomena of absorption, reflection, and transmission may be applied to the passage of light through a transparent solid. For an incident beam of intensity I_0 that impinges on the front surface of a specimen of thickness l and absorption coefficient, the transmitted intensity at the back face $I_T$is

$$I_T = I_o(1 - R)^2 e^{-\beta l}(2.7)$$

Where R is the reflectance; for this expression, it is assumed that the same medium exists outside both front and back faces. The derivation of Equation (2.2) is left as a homework problem. Thus, the fraction of incident light that is transmitted through a transparent material depends on the losses that are incurred by absorption and reflection. Again, the sum of the reflectivity R, absorptivity A, and transmisivity$T$, is unity according to Equation (2.7). Also, each of the variables R, A, and T depends on light wavelength. This is demonstrated the transmission.

2.2.5 Extinction Coefficient:

Extinction coefficient is Defines as the low voltage of the electromagnetic wave within the material which is the amount of material electrons absorbed by the energy of the falling photons and on this basis its value is combined through the interactions of the electromagnetic wave with the medium. The Extinction coefficient is calculated by the values of the absorption coefficient calculated from the absorption spectrum according to the following equation

$$K = \frac{\lambda\alpha}{4\pi}(2.8)$$

2.2.6 Bandgap energy

The fundamental absorption is related to band-to-band or to exaction transition, which are subjected to certain selection rules [48]. The transitions are classified into several types, according to the band structure of a material. The relation between absorption coefficient and optic band gap for direct transition (k=0) is given by Tau equation [14]:

$$\sqrt{\alpha h\nu} = B(h\nu - E_g^{opt})(2.9)$$

And for indirect transition ($k \neq 0$) the relation becomes

$$\alpha(h\omega) \propto \frac{(\hbar\omega - E_{gap})^2}{\hbar\omega} (2.10)$$

From the αhν versus hν one obtains $Eg$and B parameters. B is also a useful diagnostic of the material since it is inversely proportional to the extent of the tail.

2.2.7 Refractive index

Light that is transmitted into the interior of transparent materials experiences a decrease in velocity, and, as a result, is bent at the interface; this phenomenon is termed refraction.The index of refraction*n* of a material is defined as the ratio of the velocity in a vacuum *c* to the velocity in the medium or

$$n = \frac{c}{v} (2.11)$$

The magnitude of *n* (or the degree of bending) will depend on the wavelength of the light. This effect is graphically demonstrated by the familiar dispersion or se parathion of a beam of white light into its component colors by a glass prism. Each color is deflected by a different amount as it passes into and out of the glass, which results in the separation of the colors. Not only does the index of refraction affect the optical path of light, but also, as explained shortly, it influences the fraction of incident light that is reflected at the surface. Just as Equation (2.11) defines the magnitude of c, an equivalent expression gives the velocity of light in a medium as

$$\nu = \frac{1}{\sqrt{c\mu}} \quad (2.12)$$

Where ν and μ are, respectively, the permittivity and permeability of the particular substance. From equation (2.11), we have

$$n = \frac{c}{\nu} = \frac{\sqrt{\in\mu}}{\sqrt{\in_o\mu_o}} = \sqrt{\in_r\ \mu_r} \quad (2.13)$$

Where and are the dielectric constant and the relative magnetic permeability, respectively. Because most substances are only slightly magnetic, and

$$n \cong \sqrt{\in_r} \quad (2.14)$$

Thus, for transparent materials, there is a relation between the index of refraction and the dielectric constant.

2.2.8 Electrical Conductivity

Sometimes, electrical conductivityis used to specify the electrical character of a material. It is simply the reciprocal of the resistivity, or

$$\sigma = \frac{1}{\rho} \quad (2.15)$$

CHAPTER THREE

EXPERIMENTAL

CHAPTER THREE

Material and Methods

3.1 Experimental

In this work prepared as follow:

5 mM of zinc acetate ($Zn(CH3COO)_2$) and 2 mM of KOH were dissolved in methanol separately and then under continuous stirring both solutions were mixed. Prior to the start of the growth of ZnO. Acetone, isopropanol and de-ionized (DI) water were separately used under ultra sonication bath to clean the substrates. Then spin coating of the seed layer on the substrate (plastic, paper and metal coated glass) at a speed of 3000 rpm for 60 seconds. The thickness of the seed layer is controlled by adjusting the speed of the spin coater which can control the density and alignment of the ZnO. The aqueous solution of zinc nitrate ($Zn(NO_3)_2$. 6H2O) and hexamethylenetetramine (HMT) in equimolar amount of 0.1 M was prepared in a reaction vessel. The pre-seeded substrate was then immersed in the precursor solution and loaded in a laboratory oven at 50 ^{o}C for several hours (h). After the growth process the samples were soaked in DI water to remove the residuals and dried with N_2 blow. The ZnO NRs density, morphology and aspect ratio can be controlled by adjusting the reaction parameters like e.g. precursor concentration, pH value, and growth temperature and growth time [31].

3.2 Characterisation techniques

3.2.1 UV- visible device

Measurements of absorbance,emission, and permeability, ranges from 190-1100nm range for registration -3.99-3.99.

Named UV mini 1240 spectrophotometer made in a Japanese company called Shimadzumeasures two types of fluids and can measure the solids in the form of slides.The device components are: light source – a cell sample – uniform wavelength – Scout – Screen.

3.2.2 The working principle of the device

Each of the articles has a characteristic absorption of a specific wavelength. Any material have a certain extent of absorption to unchangeable but the material properties change works on the principle Berlambert based on assumptions:

- Absorbance is directly proportional to the concentration.
- Absorbance is directly proportional to the length of the optical path within the sample.

3.2.2 Spin coater

Usually a samples thin film is made by the spin coating method. It is versatile and simple .The number of round depended of the voltage, the number of round proportional increases with the voltage, then the thickness decreases with an increase in the number of rounds.

3.3 Photographic Characteristics

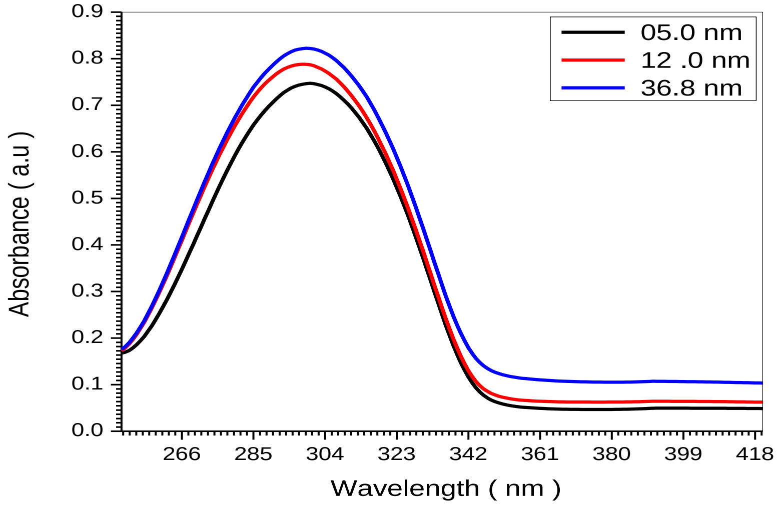

Fig (3.1) relationship between absorbance and wavelength of ZnO samples with different thickness (36.8, 12 and 5) nm

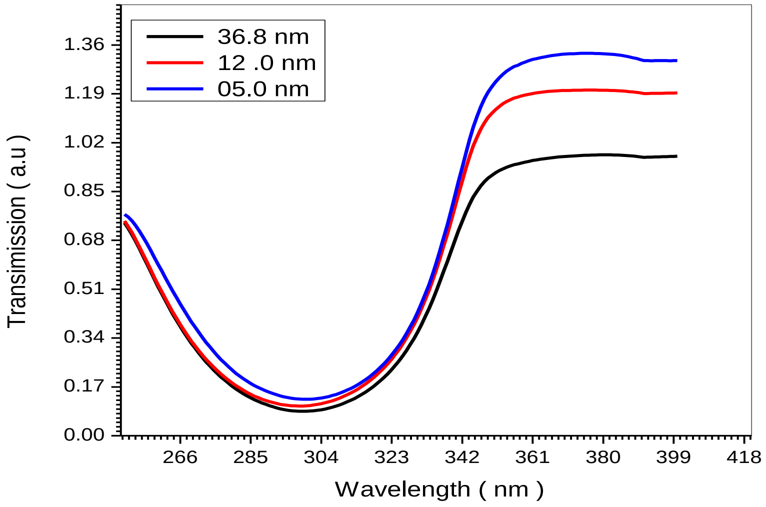

Fig (3.2) relationship between transmittance and wavelength of ZnO samples with differentthickness (36.8, 12 and 5) nm

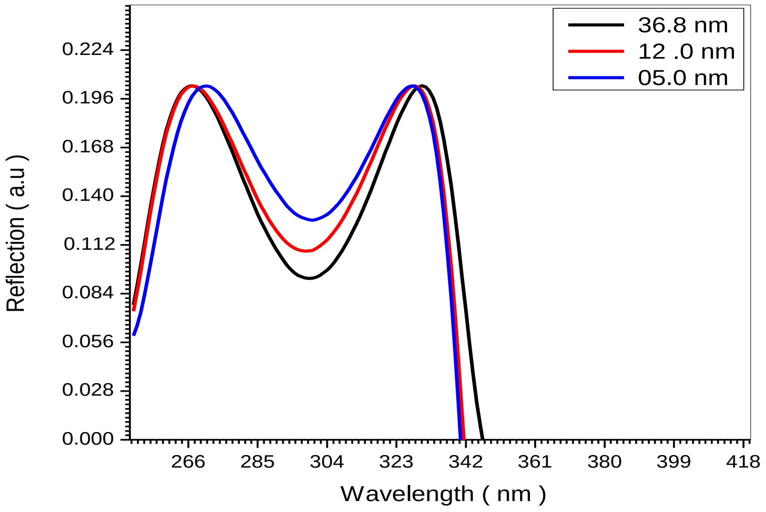

Fig (3.3) relationship between reflection and wavelength of ZnO samples with different thickness (36.8, 12 and 5) nm

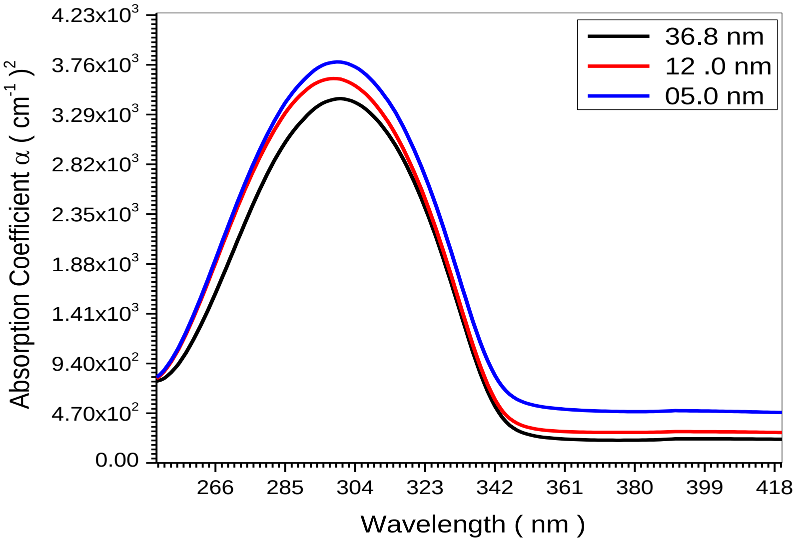

Fig (3.4) relationship between Absorption coefficient and wavelength

of ZnO samples with different thickness (36.8, 12 and 5) nm

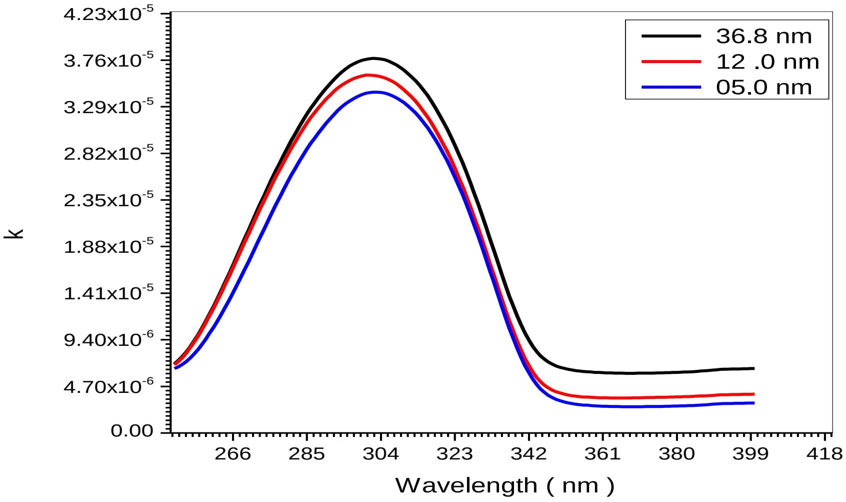

Fig (3.5) relationship between Extinction coefficient (K) and wavelength of ZnO samples with different thickness (36.8, 12 and 5) nm

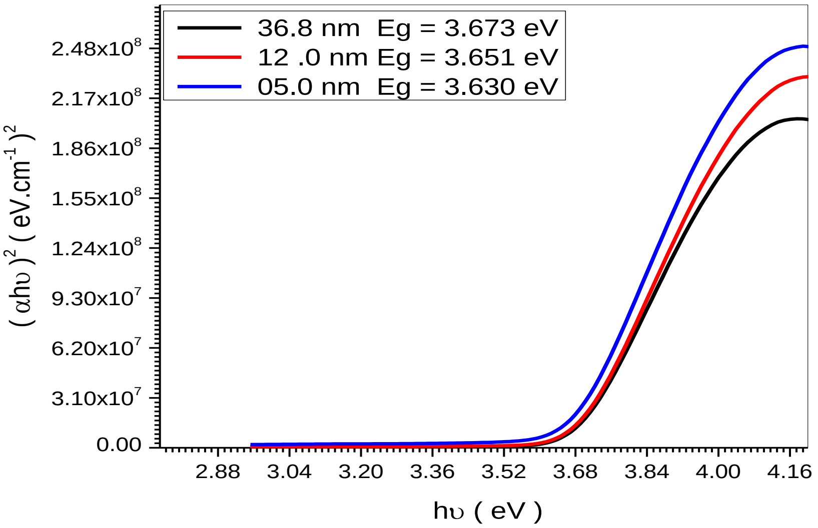

Fig (3. 6) the optical energy gap (Eg) of ZnO samples with different thickness (36.8, 12 and 5) nm

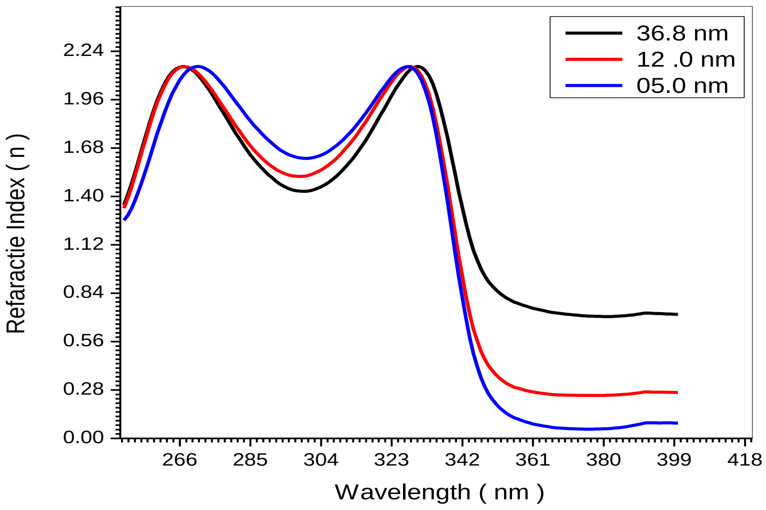

Fig (3.7) relationship between the refractive index (n) and wavelength of ZnO samples with different thickness (36.8, 12 and 5) nm

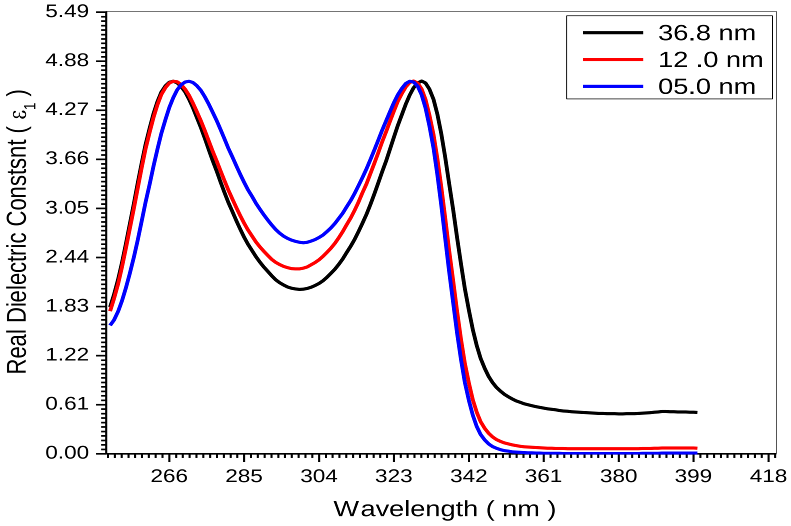

Fig (3.8) relationship between the real dielectric constant (ε_1) and wavelength of ZnO samples with different thickness (36.8, 12 and 5) nm

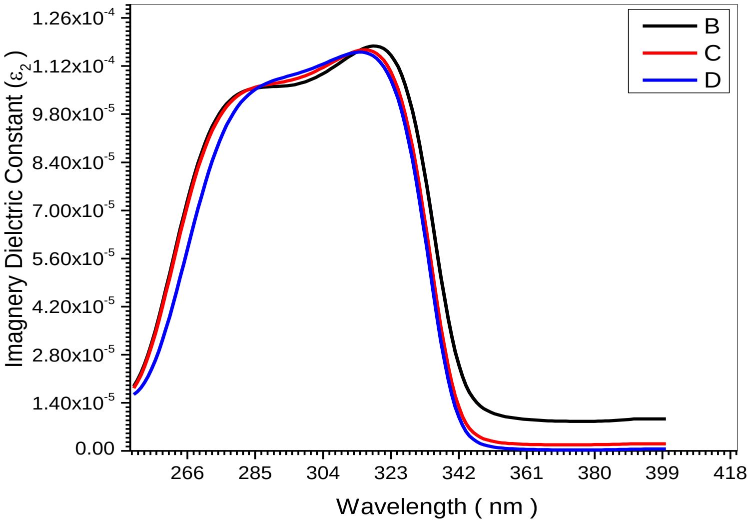

Fig (3.9) relationship between the imaginary dielectric constant (ε_2) and wavelength of ZnO samples with different thickness (36.8, 12 and 5) nm

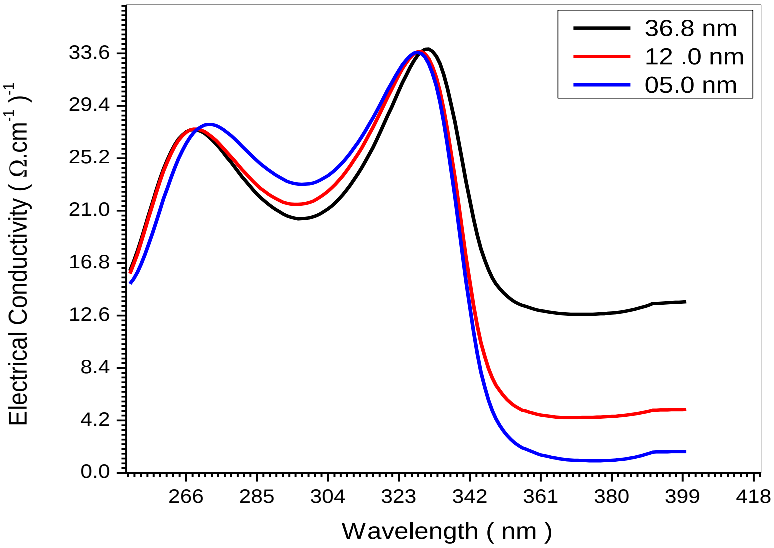

Fig (3.10) Plot of electrical conductivity as a function of wavelength for ZnO samples with different thickness (36.8, 12 and 5) nm

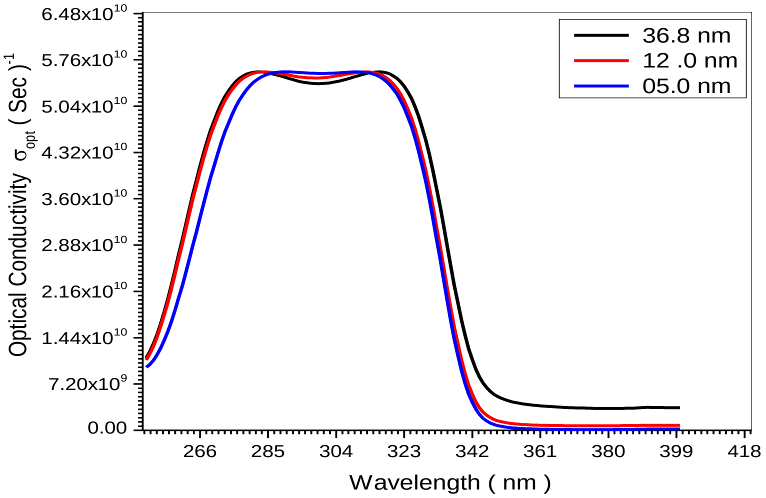

Fig (3.11) Plot of optical conductivity as a function of wavelength for ZnO samples with different thickness (36.8, 12 and 5) nm

CHAPTER FOUR

DISCUSSION AND CONTRIBUTION

CHAPTER FOUR

Discussion and contribution

4.1 Discussion

The UV- visible device was used to find the optical and electrical properties of zinc oxide with different thickness and the following contributionswereobtained:

Fig (3.1)plots the relation between absorbance and wavelength of zinc oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm which shows that:

The relation between absorbance and wavelengths, gives the same behavior of curves for all samplesof ZnO with different thickness (36.8, 12 and 5) nm studied using UV-VS min 1240 spectrophotometer, it also ensure all resolutions of absorbance in fig (3.1), besides it shows the relation between absorbance and wavelengths, which gradually increasing of the absorbance in the wavelengths (304 nm).

Fig (3.2)plots the relation between transmittance and wavelength of zinc oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm, which show that:

The transmission that discussed in this section at the region (250 - 480 nm) appears the transmittance spectra to be decreases for the sample ofzinc oxide(ZnO) with different thickness (36.8 , 12 and 5) nm, and the curves reach's the saturation above 340 nm, and the average transmittance of the samples is 1.2(au)

Fig (3.3)plots the relation between reflection and wavelength of zinc oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm, it shows the results of reflectance spectra of the sample that were treatedthezinc oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm, for the reflectance spectra of the samples ofzinc oxide(ZnO) with different thickness (36.8, 12 and 5) nm, shows a maximum value at region of ultraviolet(UV) and it decreases at the wavelength of 330 nm, which means the inverse proportional of thickness of samples with the reflection.

Fig (3.4) plots the relation between Absorption coefficient and wavelength of zinc oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm, the absorption coefficient (α) of the prepared samples of ZnO for different thickness (36.8, 12 and 5) nm were found from the following relation:

$$\alpha = 2.303\ A/t$$

Where (A) is the absorbance and (t) is the optical length on the samples, the plot of (α) with wavelength (λ) of zinc oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm, obtained that the value of $\alpha > 3.76\times10^{3}\ \text{cm}^{-1}$ for all samples in the ultraviolet(UV) region, this means that the transition must corresponds to a direct electronic transition, and the properties of this state are important since they are responsible of electric conduction. Also, it shows that the value of (α) for the samples increase while thickness decrease.

Fig (3.5)plots the relation between Extinction coefficient (K) and wavelength of oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm, extinction coefficient (K) was calculated using the relation:

$$k = \frac{\alpha\lambda}{4\pi}\ .$$

The variationat the (K) values as a function of (λ) is shown in fig (3.5) for all samples ZnO samples with different thickness (36.8, 12 and 5) nm studied, and it is observed that the spectrum shape of (K) is the same shape of (α). For the sample oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm gives the value of (K) at the (250-480 nm) region to be depend on the samples treatment method , where the value of (K) at 304 nm for 36.8 nm sample is 3.76×10^{-5} while for 5 nm samples at the same wavelength equal 3.29x10^{-5} . Also, fig (3.5) shows that the value of extinction coefficient (K) for the samples increases while thickness increase.

Fig (3.6)plots the relationbetween optical energy gap (Eg) of zinc oxide(ZnO) samples with different thickness (36.8, 12 and 5) nm, the optical energy gap (Eg) has been calculated by the relation:

$$(\alpha h\nu)^2 = C(h\nu - Eg)$$

Where C is constant,by plotting $(\alpha h\nu)^2$ vrs photon energy (hυ) for all sample treated of zinc oxide (ZnO) with different thickness (36.8, 12 and 5) nm, and by extrapolating the straight thin portion of the curve to intercept the energy axis, the value of the energy gap has been calculated, the value of (Eg) of the samples treated of ZnO obtained to be (3.673) eV, which is approach the value of (3.630) eV, and the value of (Eg) was decreased from (3.673) eV for sample 36.8 nm to (3.630) eV for the sample 5 nm. The decreasing of (Eg) related to decrease in the thickness of samples. It was observed that the different thickness of the samples confirmed the reason for the band gap shifts.

Fig (3.7)plots the relation between the refractive index (n) and wavelength of zinc oxide (ZnO) samples with different thickness (36.8, 12 and 5) nm, the refractive index (n) is the relation between speed of light in vacuum to its speed in material which does not absorb this light,the value of (n) was calculated from the equation:

$$n = \left\{ \left[\left(\frac{1+R}{1-R} \right)^2 - \left(1-k^2\right) \right] \right\}^{\frac{1}{2}} - \left[\frac{(1+R)}{(1-R)} \right]$$

Where (R) is the reflectivity,the variation of (n) vrs (λ) for all samples treatedof zinc oxide (ZnO) with different thickness (36.8, 12 and 5) nm, shown in fig (3.7), the relation of ZnO samples with different thickness (36.8,12 and 5) nm, shows that the maximum value of (n) is (2.164) for all samples at the same wavelength (330 nm), also we can show that the value of (n) begin to decrease in the (266-330 nm) region of the spectra.

Fig (3.8)plots the relation between the real dielectric constant (ε_1) and wavelength of zinc oxide (ZnO) samples with different thickness (36.8, 12 and 5) nm, it shows the variation of the real dielectric constant (ε_1) with wavelength of ZnOsamples, which calculated from the relation:

$$\varepsilon_1 = n^2 - k^2$$

Where the real the dielectric (ε_1) is the normal dielectric constant, it showsthat the variation of (ε_1) is follows the refractive index, which increased in the region that $\lambda > 350$ nm, where the absorption of the samples for these wavelength is small, but the polarization was increase, thenthe maximum value of (ε_1) equal to (4.66) for all samples at wavelength near (330) nm. The effect of thickness of ZnO thin films decreased (ε_1) with the thickness increased at (300) nm wavelength.

Fig (3.9)plots the relation between the imaginary dielectric constant (ε_2) and wavelength of ZnO samples with different thickness (36.8, 12 and 5) nm, the imaginary dielectric constant (ε_2) vrs (λ) was shown in fig (3.9),its value calculated from the equation:

$$\varepsilon_2 = 2nk$$

$\varepsilon_2$represent the absorption associated with free carriers.As shown in fig(3.9) the shape of (ε_2)is the same as (ε_1), this means that the refractive index was dominated in these behavior. The maximum values of (ε_2) are different according to the treatment operation, so the maximum value of (ε_1) equal to (4.66) for all samples at wavelength near (330) nm, while (ε_2) = $1.12x10^{-4}$ at λ = 330 nm for all samples, these behavior may be related to the different absorption mechanism for free carriers.

Fig (3.10) Plots of electrical conductivity as function of wavelength for ZnO samples with different thickness (36.8, 12 and 5) nm

Fig (3.11) Plot of optical conductivity as a function of wavelength for ZnO samples with different thickness (36.8, 12 and 5) nm

The optical conductivity is a measure of frequency response of material when irradiated with light which is determined using the following relation

$$\delta_{opt} = \frac{\alpha n c}{4\pi}$$

Where c is the speed oflight

The electrical conductivity can be estimated using the following relation $\delta_e = \frac{2\lambda\delta_{opt}}{\alpha}$.

The high magnitude of optical conductivity ($5.55x10^{10}$ sec^{-1}) confirms the presence of very high photo-response of the zinc oxide (ZnO) samples with different thickness (36.8, 12 and 5) nm. The increased of optical conductivity at (277 – 322) nm energies is due to the high absorbance of ZnO thin film and may be due to electron excitation by photon energy as it is shown in Figs (3.10) and (3.11).

4.2 Conclusion

Eleven optical properties were found by using Sop-gel technique and were found relationship between them and wavelength and were make discussion of all properties.

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