Sudan University of Science and Technology

College of Graduate Studies

Study of the optical properties of aluminum doped Zinc Oxide using Ultra Violet characterization technique.

دراسة الخصائص الضوئية لاكسيد الزنك المشوب بالالمينيوم بإستخدام تقنية الكشف بالاشعة فوق البنفسجية

A Thesis Submitted in Partial Fulfillment for the Requirements of M.Sc. in General Physics

Submitted by

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الآيـة

يقول الله سبحانه وتعالى في كتابه الكريم:

(وتلك الامثال نضربها للناس وما يعقلها الا العالمون)

(العنكبوت : 43)

Dedication

It is my pleasure to dedicate this thesis to

My mother

My father

My brothers and sisters

Who were been a source of encouragement and inspiration to me throughout my life.

Acknowledgment

I would like to express my sincere gratitude to my supervisor **Dr. Mahmoud Hamid Mahmoud Hilo** for his continuous support of me during my research, for his patience, motivation, and enthusiasm; his guidance helped me in all the time of research and writing of this thesis.

Besides my advisor, I would like to thank **Dr. Abd ElSakhi Ibrahim** for his help on the practical part of this thesis.

Finally, I would like to thank **my family** for supporting me spiritually throughout my life.

Abstract

In this work, zinc oxide nano particles were synthesized by sol-gel method, from Zinc Acetate dehydrates ($ZnC_4H_6O_4$). $2H_2O$, then the aluminum oxide was also prepared by sol-gel method from Aluminum acetate $C_6H_9AlO_6$.

Then ZnO was mixed by Al_2O_3 with concentration ratio of (0, 25, 50) % to get four samples of AZO, these samples were characterized with UV-VIS spectrometer, and the optical properties of AZO were studied.

It is clearly seen that the energy gap decrease with increasing of the Al doping ratio, and the absorption decrease with increase of the Aluminum concentration, the maximum transmission observed at Aluminum concentration of 25%.

The attenuation coefficient has low value at low concentration, but it increases with the increasing of the concentration of Aluminum. These results show that the ratio of 50% of the Aluminum does not make any difference in the absorption, and the perfect doping or mixing takes place only at concentrations low than 25%.

المستخلص

في هذا البحث تم تحضير أكسيد الزنك النانوي بطريقة المحلول الجلاتيني من خلات الزنك المائية $(ZnC_4H_6O_4).2H_2O$، من ثم تم تحضير الالمنيوم بطريقة المحلول الجلاتيني من $C_6H_9AlO_6$.

تم مزج اكسيد الزنك المحضر بأكسيد الالمنيوم بمعدل تركيز (0, 25, 50)% للحصول على اربعة عينات من AZO، وتم فحص العينات بإستخدام مطياف الاشعة فوق البنفسجية والمرئية.

ومن ثم تم دراسة الخواص الضوئية للعينات.

اتضح من خلال الرسم البياني ان فجوة الطاقة تتناقص بزيادة تركيز الالمنيوم وان الامتصاصية تتناقص ايضاً بزيادة تركيز الالمينيوم، اقصي انتقال يحدث عند تركيز 25% للالمينيوم ومعامل التوهين تكون له اقل قيمة عند تركيز اقل ويزيد بزيادة التركيز.

هذه النتائج توضح ان نسبة ال 50% من الالمينيوم لا تحدث اي تغيير في الامتصاصية وهذا يعني ان القيم الفعالة للتشويب تكون في حدود اقل من 25% للتركيز.

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Chapter one

Introduction

Chapter one

1.1 Introduction

Zinc oxide, with its unique physical and chemical properties, such as high chemical stability, high electrochemical coupling coefficient, broad range between ionized and non ionized radiation absorption and high photo stability, is a multifunctional material. [1] One of the better-known materials that have been widely used for medical applications is zinc oxide nano particles. [2]. A wide band gap (3.4 eV) II–VI compound semiconductor, has a stable wurtzite structure with lattice spacing a = 0 - 325 nm and c = 0 -521 nm [3]. Zinc oxide (ZnO) is a widely studied material because it is inexpensive and nontoxic with remarkable optical, electrical and chemical properties.

These properties made ZnO suitable for realization of many applications in electrostatic dissipation (ESD), electromagnetic interference (EMI) shielding, radio frequency interference (RFI) shielding, and so on Zinc Oxide. [4] It have found widespread application in a range of industries, including use as solar cells, photocatalysts, gas sensors, optoelectronic devices4 and photonic devices,5 due to their exceptional properties. [5]

(ZnO) is a great interesting material due to their advantage in widely range of technology applications, low coat, non-toxic, resource availability and high physical/chemical stability. It is a wide band gap semiconductor, which has direct band gap width of 3.37eV. In order to improve electrical and optical properties, ZnO film has been doped with many metal elements. Impurity doping such as Al, In, Ga, B affected to high electrical conductivity. Among these elements, Al doped ZnO are considered as an alternative for transparent conducting oxide material (TCO) for solar cell and light emitting diodes (LEDs). The atomic substitution of Al to Zn in ZnO crystal structure has occurred a free electron in conduction band, which provides a reduction in its electrical resistivity. This material exhibits high transparency and low resistivity [5]. AZO have been prepared by various methods such as sol-gel processing, magnetron sputtering, and atomic layer deposition. These methods have been done under controlled environment that leads to complicate in the process and high cost. [6]

.1.2Nanotechnology

Nanotechnology is a rapidly developing discipline, which allows the fabrication of novel, hitherto unknown nano structured materials, featured with unique properties and multiple possibilities of application. Such nano materials can exhibit altered spectroscopic, magnetic, structural and biological properties. [7]

Nanotechnology is widely considered to constitute the basis of the next technological revolution following on from the first industrial revolution, which began around 1750 with the introduction of the steam engine and steelmaking. [8]

The term nanotechnology comes from the combination of two words: the Greek numerical prefix nano referring to a billionth and the word technology. As an outcome, Nanotechnology or Nano scaled Technology is generally considered to be at a size below 0:1 _m or 100 nm (a nanometer is one billionth of a meter, 10_9 m). Nano scale science (or nano science) studies the phenomena, properties, and responses of materials at atomic, molecular, and macromolecular scales, and in general at sizes between 1 and 100 nm. In this scale, and especially below 5 nm, the properties of matter differ significantly from that at a larger particulate scale. Nanotechnology is then the design, the manipulation, the building, the production and application, by controlling the shape and size, the properties-responses and functionality of structures, and devices and systems of the order or less than 100 nm.

Nanotechnology is considered an emerging technology due to the possibility to advance well-established products and to create new products with totally new characteristics and functions with enormous potential in a wide range of applications. In addition to various industrial uses, great innovations are fore seen in information and communication technology, in biology and biotechnology, in medicine and medical technology, in metrology, etc. Significant applications of nano sciences and nano engineering lie in the fields of pharmaceutics, cosmetics, processed food, chemical engineering, high-performance materials, electronics, precision mechanics, optics, energy production, and environmental sciences.

Nanotechnology is an emerging and dynamic field where over 50,000 nanotechnology articles have been published annually worldwide in recent years, and more than 2,500 patents are filed at major patent offices such as the European Patent Office.

Nanotechnology can help in solving serious humanity problems such as energy adequacy, climate change or fatal diseases: “Nanotechnology” Alcatel-Lucent is an area which has highly promising prospects for turning fundamental research into successful innovations. Not only to boost the competitiveness of our industry but also to create new products that will make positive changes in the lives of our citizens, be it in medicine, environment, electronics or any other field. Nano sciences and nanotechnologies open up new avenues of research and lead to new, useful, and sometimes unexpected applications. Novel materials and new-engineered surface sallow making products that perform better. New medical treatments are emerging for fatal diseases, such as brain tumors and Alzheimer’s disease. Computers are built with nano scale components and improving their performance depends upon shrinking these dimensions yet further. [9]

1.2.1Properties of nano materials

A nano material is an object which has, at least, one dimension in the nanometer scale, which is conventionally ranging from one to a few hundred nanometers. [10]

Nano materials with unique properties such as: nano particles carbon nano tubes, fullerenes, quantum dots, quantum wires, nano fibers, and nano composites allow completely new applications to be found. Products containing engineered nano materials are already in the market. The range of commercial products available today is very broad, including metals, ceramics, polymers, smart textiles, cosmetics, sunscreens, electronics, paints and varnishes. However new methodologies and instrumentation have to be developed in order to increase our knowledge and information on their properties. [11]

1.3 Research Objective

This research aims to study the optical properties specific Absorbance, Transmittance, Reflection, Extinction coefficient, Absorption coefficient and Energy gab of aluminum doped Zinc Oxide to improve its electronics uses by Ultra Violet (UV –VIS) characterization technique.

1.4 Research Method

In this research the experimental (practical) method is used to study the optical properties of AZO using the Ultra Violet characterization technique.

1.5 Research Problem

Developing the structural, optical, electrical, thermal and magnetic characteristic of materials in their both bulk and nano size is one of the important issues in scientific research, for that reason searching properties for the aluminum doped zinc oxide is sound, and supports the manufactures uses of it in their nano scale.

1.6 Research Layout

This research consist of four chapters as follow

Chapter one is intended for the introduction, while chapter tow is for the theoretical background and literature review. Chapter three provides the experimental work of synthesized ZnO: Al, beside, the results and a detailed description of the actual equipments and tools used, and the techniques carried out for optical characterization. Chapter four gives the discussion of the results of the optical characteristics and the conclusion of the present work.

Chapter two

Theoretical background and Literature Review

Chapter two
Theoretical background and Literature Review

2.1. Crystal Structure of ZnO

Most of the group II–VI binary compound in either cubic zinc blende or hexagonal wurtzite (Wz) structure where each anion is surrounded by four cations at the corners of a tetrahedron, and vice versa. This tetrahedral coordination is typical of sp3 covalent bonding nature, but these materials also have a substantial ionic character that tends to increase the band gap beyond the one expected from the covalent bonding. [12] Crystalline ZnO has a wurtzite (B4) crystal structure at ambient conditions. The ZnO wurtzite structure has a hexagonal unit cell with two lattice parameters, a and c, and belongs to the space group of C46V or P63mc. Figure 1 clearly shows that the structure is composed of two interpenetrating hexagonal closed packed (hcp) sublattices, in which each consist of one type of atom (Zn or O) displaced with respect to each other along the threefold c-axis. It can be simply explained schematically as a number of alternating planes stacked layer-by-layer along the c-axis direction and composed of tetrahedrally coordinated Zn2+ and O2−. The tetrahedral coordination of ZnO gives rise to the noncenter symmetric structure. In wurtzite hexagonal ZnO, each anion is surrounded by four cations at the corners of the tetrahedron, which shows the tetrahedral coordination and hence exhibits the sp3 covalent-bonding. [13]

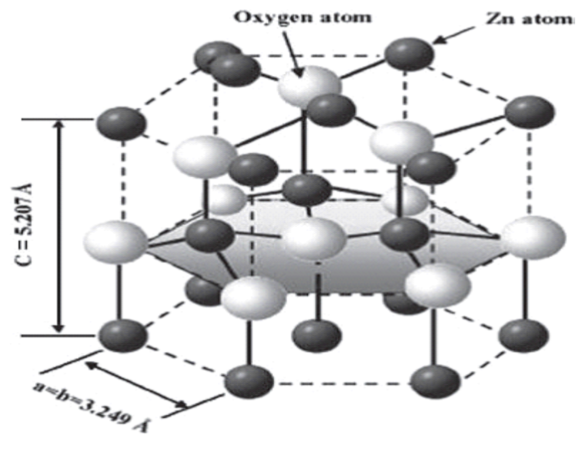

Figure 1 Crystal Structure of ZnO

2.2 Properties of ZnO and its Dopants Materials

The properties of ZnO thin film in optical, acoustical and electrical properties meet good applications in the field of electronics, optoelectronics and sensors. ZnO used in a solar cell window and transparent conductive film because of optical transmittance is high in the visible region. Due to their excellent piezoelectric properties, ZnO materials applied to a surface acoustic wave device and film bulk acoustic resonator. The techniques involved in ZnO thin film are spray pyrolysis, sputtering, sol-gel spin coating, and chemical vapor deposition and pulsed laser deposition. ZnO give rise to strong pyro electric and piezoelectric properties. Compared to pure anataseor rutile phase, mixed phase of anatase and rutile have higher photocatalytic activity**.**

This property makes ZnO useful as an additive. This also increases the appeal of ZnO as a substrate for homoepitaxy or heteroepitaxy. High thermal conductivity translates into high efficiency of heat removal during device operation. It has been reported that ZnO can be etched with acidic, alkaline as well as mixture solutions. The possibility of low-temperature chemical etching adds great flexibility in the processing, designing and integration of electronic and optoelectronic devices. Radiation hardness is important for applications at high altitude or in space. It has been observed that ZnO exhibits exceptionally high radiation hardness, even greater than that of GaN, the cause of which is still unknown. Conductivity of ZnO is very sensitive to the exposure of the surface to various gases. It can be used as a ‘cheap smell sensor’ capable of detecting the freshness of foods and drinks, due to the high sensitivity to tri methylamine present in the odour. Recent experiments reveal the existence of a surface electron accumulation layer in vacuum-annealed single crystals, which disappears upon exposure to ambient air. This layer may play a role in sensor action, as well. The structural, morphological, optical and electrical properties of ZnO can be modified with proper doping. For higher conductivity of ZnO-based thin films, various tetravalent metal dopants are added to ZnO films, such as Ti, Sn, Ga and Si etc. [14]

Band-gap engineering of ZnO can be achieved by alloying with MgO or CdO. Adding Mg to ZnO increases the band gap, whereas Cd decreases the band gap, similar to the effects of Al and In in GaN. Although MgO and CdO crystallize in the rocksalt structure, for moderate concentrations the $Mg_{1-x}Zn_xO$ and $Cd_{1-x}Zn_xO$ alloys assume the wurtzite structure of the parent compound, while still leading to significant band-gap variation [15].

Various methods have been reported for the syntheses of ZnO nanoparticles, including precipitation, spray pyrolysis, hydrothermal, sol-gel, thermal evaporation, mechanical and mechanochemical methods. The common disadvantages of this method include the wide distribution of particle diameter, as well as the expensive raw materials. [16]

2.3Applications of ZnO nanostructure

Zinc oxide is known for its antibacterial properties from the time immemorial. It had been in use during the regime of Pharaohs, and historical records show that zinc oxide was used in many ointments for the treatment of injuries and boils even in 2000 BC. [17]

In dentistry, ZnO alone or together with eugenol is used as a fill material due to its ability to block microbial leakage. For this reason, ZnO usually is included in the temporary cementation material for cementation of temporary crowns and bridges. [18]

ZnO is a bio-safe and biocompatible material and can be directly used for biomedical applications without coating. Due to the novel and exceptional properties of ZnO, much effort has been directed to the fabrication of ZnO with interesting morphologies and assemblies. [29] ZnO has wide application in surface acoustic wave devices, field emission, gas sensors, ceramics, solar cells and ultraviolet nanolasers. [20]

2.3Aluminum

Aluminum is the third most abundant element in the earth's crust (7.4%). It never exists free in nature and it is usually bound to oxygen (alumina) or to other elements like fluorine (cryolite (Na_3AlF_6)). It is one of the major constituents of naturally available minerals like feldspars, zeolites, and micas. The majority of aluminum compounds known have a formal oxidation state of +3 for the aluminum atom and this can be attributed to the high stability of +3 oxidation state. The Hall– He´roult process, which involves electrolysis of Al2O3 dissolved in cryolite, is the widely employed process in the production of aluminum metal. The area of low valent aluminum chemistry although less explored is quite intriguing and exciting from the perspective of synthetic methodology, structure and theoretical implications. On account of these factors a significant increase in the synthesis of these low valent aluminum compounds has been observed in the past decade. In this feature article we report the development of aluminum(I) chemistry in the last decade as well as the paradigm shift in the synthesis of monomeric aluminum(I) compounds from tetramers and its utility in the preparation of aluminum heterocycles hitherto not possible in conventional ways [21].

2.3.1 Aluminum as the dopants of ZnO

When ZnO is doped Al, Al3+ substitutes Zn2+ site in the ZnO crystal structure resulting in one more free electron to contribute to the electric conduction. Furthermore, Zn can be easily substituted by Al because the aluminum radius is smaller than that of zinc ($r_{Zn}{}^{2+}$ = 0.074 nm and $r_{Al}{}^{3+}$ = 0.05 nm) Al substituting Zn is therefore a good candidate as an n-type dopants in ZnO. [22]

Among all dopants, Al which is found to be cheap, abundant as well as a non-toxic material finds its attention because of high temperature stability, non-degradation, good stability in hydrogen plasma, enhanced electrical conductivity. [23]

Aluminum- doped ZnO (AZO) powders are both conductive and transparent in the visible region and thus can be utilized in transparent conductive composites. Many techniques have been developed to synthesize AZO, such as the solvothermal method, sol–gel method, thermal evaporation method, vapor deposition method, pulsed laser deposition method, magnetron sputtering method and coprecipitation method. [24]

2.4 optical properties of materials

2.4.1 Absorption

During absorption, the intensity of an incident electromagnetic wave is attenuated in passing through a medium. The absorbance of a medium is defined as the ratio of absorbed and incident intensities. Absorption is due to a partial conversion of light energy into heat motion or certain vibrations of molecules of the absorbing material. A perfectly transparent medium permits the passage of light without any absorption.

The terms “transparent” and “opaque” are relative, since they certainly are wavelength-dependent. Cornea and lens, for instance, mainly consist of water which shows a strong absorption at wavelengths in the infrared spectrum. Hence, these tissues appear opaque in this spectral region. Actually, no medium is known to be either transparent or opaque to all wavelengths of the electromagnetic spectrum.

A substance is said to show general absorption if it reduces the intensity of all wavelengths in the considered spectrum by a similar fraction. In the case of visible light, such substances will thus appear grey to our eye. Selective absorption, on the other hand, is the absorption of certain wavelengths in preference to others. The existence of colors actually originates from selective absorption. Usually, body colors and surface colors are distinguished.

Body color is generated by light which penetrates a certain distance into the substance. By backscattering, it is then deviated and escapes backwards from the surface but only after being partially absorbed at selected wavelengths.

In contrast, surface color originates from reflection at the surface itself. It mainly depends on the reflectances which are related to the wavelength of incident radiation by.

The ability of a medium to absorb electromagnetic radiation depends on a number of factors, mainly the electronic constitution of its atoms and molecules, the wavelength of radiation, the thickness of the absorbing layer, and internal parameters such as the temperature or concentration of absorbing agents. Two laws are frequently applied which describe the effect of either thickness or concentration on absorption, respectively. They are commonly called Lambert's law and Beer's law, and are expressed by

$$I(z) = I_0 \exp(-\alpha z) ,$$

$$\text{And } I(z) = I_0 \exp(-k\_cz) ,$$

where z denotes the optical axis, I(z) is the intensity at a distance z, I0 is the incident intensity, α is the absorption coefficient of the medium, c is the concentration of absorbing agents, and k' depends on internal parameters other than concentration. Since both laws describe the same behavior of absorption, they are also known as the Lambert–Beer law.

2.4.2 Reflection

Reflection is defined as the returning of electromagnetic radiation by surfaces upon which it is incident. In general, a reflecting surface is the physical boundary between two materials of different indices of refraction such as air and tissue. The simple law of reflection requires the wave normals of the incident and reflected beams and the normal of the reflecting surface to lie within one plane, called the plane of incidence. It also states that the reflection angle θ' equals the angle of incidence θ.

$$\theta = \theta'$$

The angles θ and θ' are measured between the surface normal and the incident and reflected beams, respectively. The surface itself is assumed to be smooth, with surface irregularities being small compared to the wavelength of radiation.

Refraction usually occurs when the reflecting surface separates two media of different indices of refraction. It originates from a change in speed of the light wave. The simple mathematical relation governing refraction is known as Snell's law.

2.4.3 Attenuation coefficient

The attenuation coefficient is a quantity that characterizes how easily a material or medium can be penetrated by a beam of light, sound, particles, or other energy or matter. A large attenuation coefficient means that the beam is quickly "attenuated" (weakened) as it passes through the medium, and a small attenuation coefficient means that the medium is relatively transparent to the beam. The attenuation coefficient is a measure of the interaction probability (called cross-section) of the gamma rays with the matter or the target. It is obtained by summing the contributions of the three effects: the photoelectric effect, the Compton effect, and (to a lesser degree) pair-production. Attenuation coefficient is measured using units of reciprocal length.

The measured intensity I transmitted through a layer of material with thickness x is related to the incident intensity I0 according to the inverse exponential power law that is usually referred to as Beer–Lambert law:

$$I=I0e-\mu x$$

Where, x denotes the path length. The attenuation coefficient (or linear attenuation coefficient) is μ

The linear attenuation coefficient (μ) describes the fraction of a beam of x-rays or gamma rays that is absorbed or scattered per unit thickness of the absorber. This value basically accounts for the number of atoms in a cubic cm volume of material and the probability of a photon being scattered or absorbed from the nucleus or an electron of one of these atoms. The linear attenuation coefficient is also inversely related to mean free path.

2.4.4 The Absorption Coefficient

Measurement of the absorption of light is one of the most important techniques for optical measurements in solids. In the absorption measurements, we are concerned with the light intensity I(z) after traversal of a thickness z of material as compared with the incident intensity I_0, thereby defining the absorption Coefficient $\alpha_{abs}(\acute{\omega})$:

$I(z) = I_0e\ \alpha_{abs}(\acute{\omega})z$ Since the intensity I(z) depends on the square of the field variables. Where the factor of 2 results from the definition of $\alpha_{abs}(\acute{\omega})$ in terms of the light intensity, which is proportional to the square of the fields. This expression tells us that the absorption Coefficient is proportional to ~k(!), the imaginary part of the complex index of refraction (Extinction Coefficient), so that ~k is usually associated with power loss.

2.4.5 Scattering

When elastically bound charged particles are exposed to electromagnetic waves, the particles are set into motion by the electric field. If the frequency of the wave equals the natural frequency of free vibrations of a particle, resonance occurs being accompanied by a considerable amount of absorption. Scattering takes place at frequencies not corresponding to those natural frequencies of particles. The resulting oscillation is determined by forced vibration. In general, this vibration will have the same frequency and direction as that of the electric force in the incident wave. Its amplitude, however, is much smaller than in the case of resonance. Also, the phase of the forced vibration differs from the incident wave, causing photons to slow down when penetrating into a denser medium. Scattering can be regarded as the basic origin of dispersion.

Elastic and inelastic scattering are distinguished, depending on whether part of the incident photon energy is converted during the process of scattering. In the following paragraphs, we will first consider elastic scattering, where incident and scattered photons have the same energy. A special kind of elastic scattering is Rayleigh scattering. Its only restriction is that the scattering particles be smaller than the wavelength of incident radiation. In particular, we will find a relationship between scattered intensity and index of refraction, and that scattering is inversely proportional to the fourth power of wavelength.

2.4.6 The refractive index

Refractive index is the ratio of the speed of light in air and matter, Many materials have a well-characterized refractive index, but these indices depend strongly upon the wavelength of light.

Therefore, any numeric value for the index is meaningless unless the associated wavelength is specified. There are also weaker dependencies on temperature, pressure, and stress, as well on the precise material compositions (including the presence of impurities and dopants). However, these variations are usually at the percent level or less. Thus, it is especially important to cite the source for an index measurement if high precision is claimed. [25]

2.5 UV-visible spectroscopy

When radiation interacts with matter, a number of processes can occur, including reflection, scattering, absorbance, fluorescence/phosphorescence (absorption and reemission), and photochemical reaction (absorbance and bond breaking). In general, when measuring UV-visible spectra, we want only absorbance to occur. [28] Spectroscopic investigations of solutions, gas phase and individual crystals usually take place in transmission, but it is very difficult to obtain transparent films of powders and solids, making transmission experiments almost impossible. The wavelength of UV is shorter than the visible light. It ranges from 100 to 400 nm. In a standard UV-V is spectrophotometer, a beam of light is split; one half of the beam (the sample beam) is directed through a transparent cell containing a solution of the compound being analyzed, and one half (the reference beam) is directed through an identical cell that does not contain the compound but contains the solvent. The instrument is designed so that it can make a comparison of the intensities of the two beams as it scans over the desired region of the wavelengths. If the compound absorbs light at a particular wavelength, the intensity of the sample beam (IS) will be less than that of the reference beam. Absorption of radiation by a sample is measured at various wavelengths and plotted by a recorder to give the spectrum which is a plot of the wavelength of the entire region versus the absorption (A) of light at each wavelength. And the band gap of the sample can be obtained by plotting the graph between (αhνvshν) and extrapolating it along x-axis. Ultraviolet and visible spectrometry is almost entirely used for quantitative analysis; that is, the estimation of the amount of a compound known to be present in the sample. The sample is usually examined in solution. [26]

2.5 Literature Review

M. Maache , T. Devers , A. Chala were successful in preparing Pure zinc oxide and aluminum doped zinc oxide films onto glass substrates by spin coating, The measurements show that the films are nanostructured. The transmittance is greater than 75% in the visible region. The band gap energy decreases with the addition of dopant (Al) in prepared thin films and the resistivity decreases significantly. [27]

A Sukee, E Kantarak, P Singjai deposited Aluminum doped Zinc Oxide (AZO) nanoparticle thin films on glass substrates by a double tip sparking process. The doping ratios of Al into ZnO were 3, 5, 7, 13 and 22%. SEM images indicated particle size decreased with increasing the Al content after annealing.

AZO films have an average transmittance in visible region at 60 %. The energy gap increased with increasing Al content. The minimum resistivity was found at 5 % of Al doping for AZO film. [28]

Ruoyu Ray was successfully prerared Aluminum-doped zinc oxide (AZO) powder synthesized by coprecipitation. The resistivity of the AZO powders reached a minimum value at the optimum condition: Al doping concentration is at 1.5 at.%, the postcalcination temperature is at 900 C, and the holding time is 2 h. [29]

Chapter three

Experimental and results

Chapter three

Experimental and results

3.1 Materials

Zinc Acetate dehydrates ($ZnC4H6O4$). $2H2O$ 2.1g

Hexamethylenetetramine (HMTA) ($C6H12N4$)1.4g

Aluminum acetate $C6H9AlO6$ 7.0g

Deionized water

3.2 Equepments

3.2.2Magnetic stirrer

Magnetic stirrer used to stirring the mixer liquids

3.2.3 UV characterization

UV-vis spectrometer used to study the optical properties of AZO

3.3 Experimental setup

- Al-doped ZnO were prepared by sol-gel method based on zinc acetate dehydrate ($(CH3COO)_2$ Zn•2H2O) Aluminum acetate ($C4H7AlO5$), And Hexamethylenetetramine (HMTA) ($C6H12N4$)

- The solution was prepared with various Al composition x = 25% and 50%.

- To prepare ZnO, 21.85 ml from ZnO with 39.8 ml of Hexamethylenetetramine all solved in ionized water with starring for 1 hour.

- In preparing Aluminum, 31.3 ml from Aluminum acetate solved with 46.7ml from Hexamethylenetetramine in ionized water with starring for 1 hour.

- I taked various Al and ZnO composition and solved each other in ice medium for 1 hour.

- Optical properties of samples studied using UV UV-vis spectrometer

3.4 Results

Sample 1 represent pure AL, sample 2 represent AL 50%, sample 3 represent AL 25% and sample 4 represent pure Zn

Determination of the optical properties of the AZO

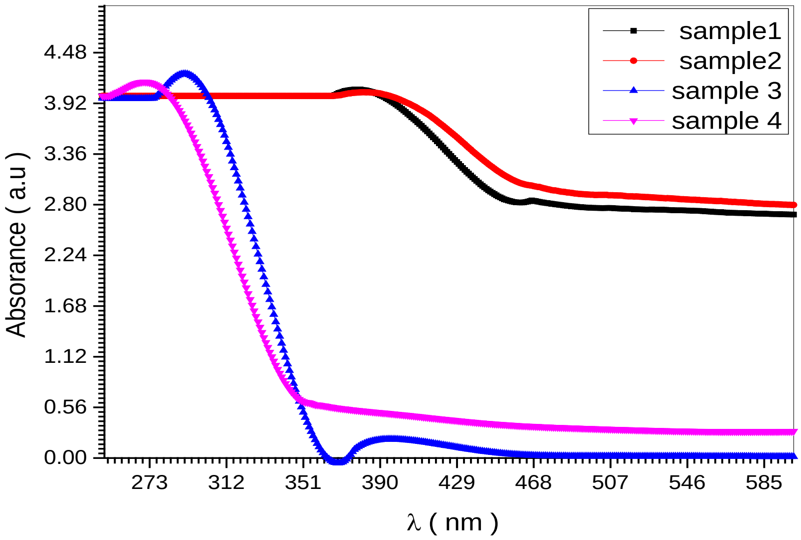

Figure: 1 Absorbance spectra of AZO

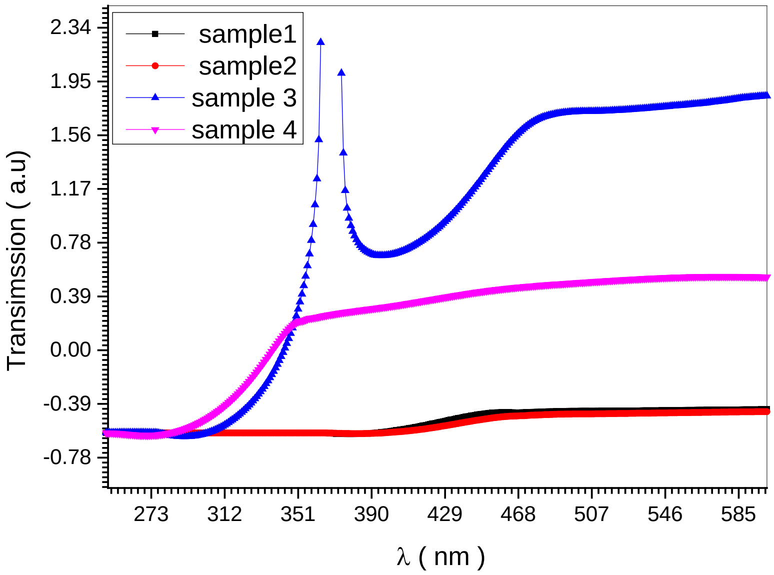

Figure: 2 Transmittance spectra of AZO

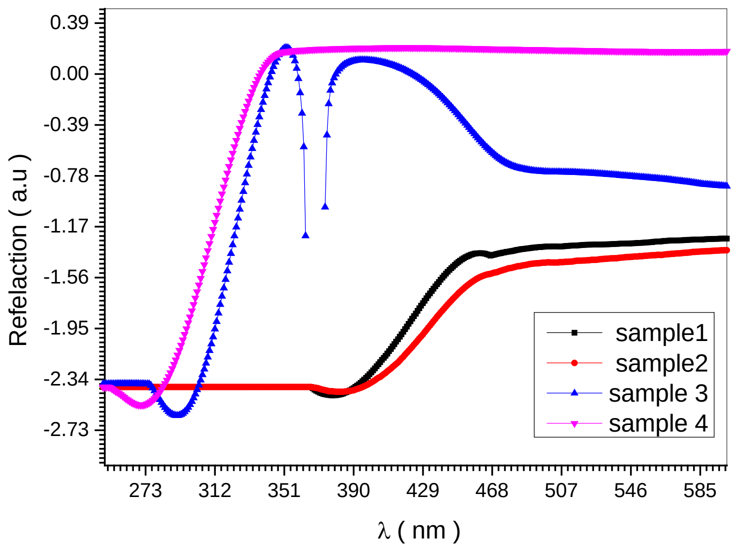

Figure: 3 Reflection spectra of AZO

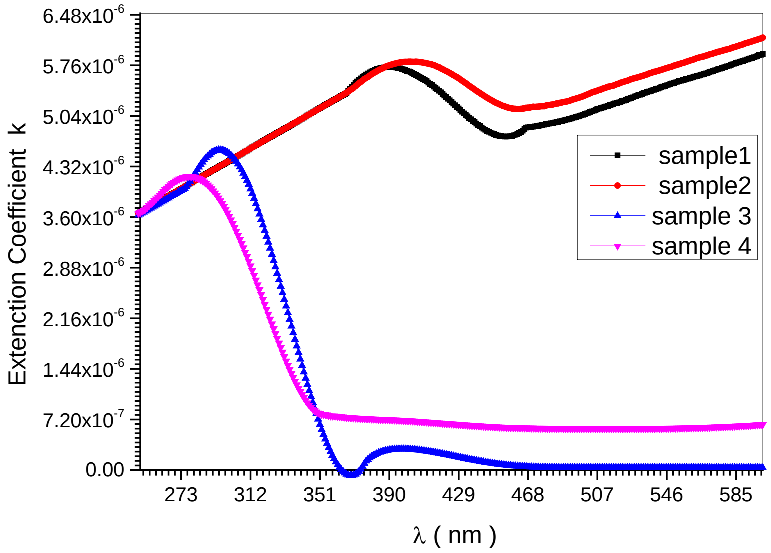

Figure: 4 Extinction coefficient of AZO

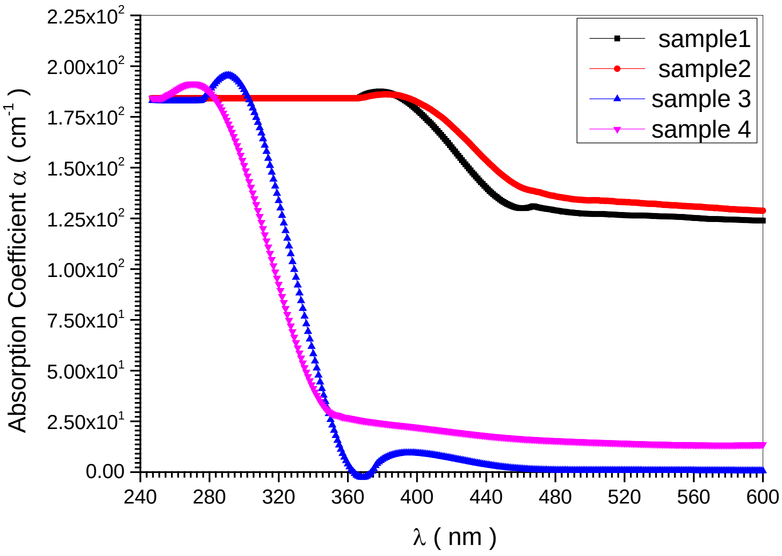

Figure: 5 Absorption coefficient of AZO

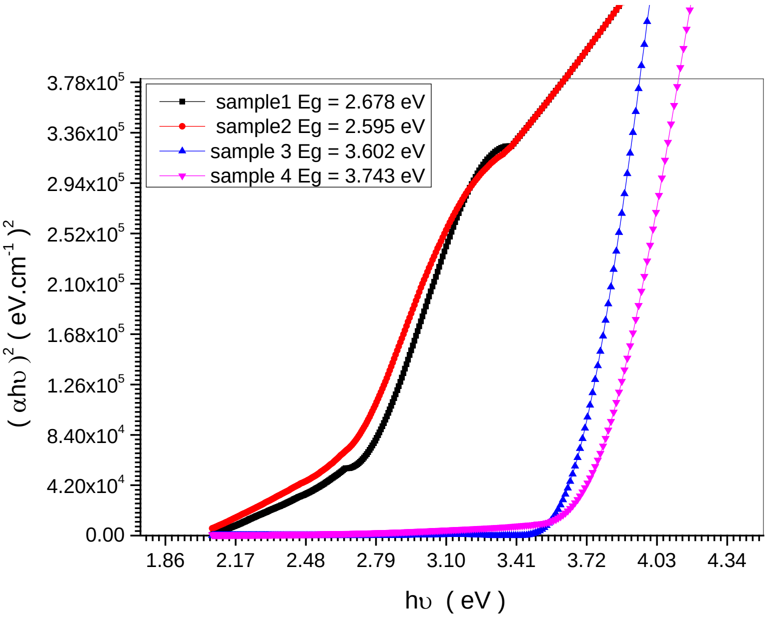

Figure: 6 Energy gab of AZO

Chapter four

Discussion and conclusion

Chapter four

Discussion and conclusion

4.1 Discussion

The optical absorption spectra for the AZO samples are depicted in Fig.1 maximum absorption for sample 1 (AL 0%) observed at wavelength (273-312 nm) region, for sample 2 (AL 50%) the maximum absorption observed at wavelength (351-410 nm) region, for sample 3 (AL 25%) the maximum absorption observed at wavelength (351-390 nm) region, for sample 4 (Zn 0%) the maximum absorption observed at wavelength (236-273 nm) region.

The optical transmission spectra for the AZO samples are depicted in Fig. 2 transmittance spectra for sample 1 decrease at the wavelength (>390 nm) the curves reach's saturation above 440 nm

The transmittance spectra for sample 2 decrease at the wavelength (>390 nm) the curves reach's saturation above 440 nm

The transmittance spectra for sample 3decrease at the wavelength (>312 nm) and it has a maximum value at region (351-370 nm) the curves reach's saturation above 468 nm.

The transmittance spectra for sample 4 decrease at the wavelength (>312 nm) the curves reach's saturation above 351 nm

The optical reflection spectra for the AZOsamples are depicted in Fig. 3 Reflectance spectra for sample 1 increases in the wavelength region (390-468) nm and it has a maximum value at (468 nm)

Reflectance spectra for sample 2 increases in the wavelength region (390-468) nm and it has a maximum value at (468 nm)

Reflectance spectra for sample 3 increases in the wavelength region (290-351) nm.

Reflectance spectra for sample 4 increases in the wavelength region (273-340) nm the curves reach's saturation above 351 nm

The change of the Attenuation coefficient as a function of the wavelength is shown in Figure (4) for (s1, s2) it can be noted that (k) has low value at low concentration, but it increases with the increasing of the concentration of (Al). This is attributed to increase absorption coefficient with the increase of weight percentages of (Al) figure (3) shows that before 390 (nm) the absorbance increases with increasing of wavelength, this is because of the presence of defects inside the structure where absorb this energy and organize the selves to stabilizing then after 390 (nm) the absorbance decreases with increasing of wavelength and return to increases with increasing of wavelength.

The decrease of attenuation coefficient with the increase of wavelength in the sample 3, 4 indicates that the fraction of light lost due to scattering and absorbance decreases. It is obvious that, the attenuation coefficientat each composition has the tendency to increase towards lower wavelengths corresponding to the beginning of strong electronic absorption.

Absorption coefficient for the AZO samples is depicted in Fig. 5 absorption coefficient for samples 3, 4 is the smallest at high wavelength and low energy; this means that the possibility of electron transition is little because the energy of the incident photon is not sufficient to move the electron from the valence band to the conduction band ($h\upsilon<Eg$) at high energies, absorption is bigger.

Figure 6 shows variations of $(\alpha h\upsilon)^2$vrs Photon energy hυ for pure ZnO , pure Al and ZnO :Al (y= 50%, and 25%). The estimated Eg values for ZnO:Al are 2.678, 3.602, and 2.595 eV for y= 0, 25%, and 50% respectively. Thus, it can be concluded that energy gap decreased with increasing the Al doping ratio

4.2 CONCLUSION

Aluminum doped Zinc oxide nanoparticles were synthesized through sol-gel method with various Al composition x =0, 25% and 50%.. The results of the UV-VIS showed that energy gap decreased with increasing the Al doping ratio. The maximum absorption decrease with increase Al concentration, the maximum transmission observed at Al 25%.

The extinction coefficient has low value at low concentration, but it increases with the increasing of the concentration of (Al).

4.3 References

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