Sudan university of science and technology

College of graduate studies

The Optical Properties of Silicon Dioxide Doped By Iodine, Coumarin 500 and Rhodamine B

الخصائص البصرية لثاني أكسيد السيلكون المطعم باليود والكومرين 500 والرودومين بي

A Thesis submitted in partial fulfillment of the requirement for the degree of M.sc. in physics

By :

Khalid Mustafa Abdalrhman Momin

Supervisor :

Dr . Rawia Abdelgani Elobaid

May 2018

الإستهلال

قال الله تعالى :

بسم الله الرحمن الرحيم

(قالو سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم)

صدق الله العظيم

البقرة الآية(32)

Dedication

To my mother

Un known soldier in our home

To spirit my father

It is the greatest love that he holds

To science and knowledge

To my brothers and sisters

To my teachers

To all my friends

Acknowledgement

Before of all , the praise and thanks be to Allah whom to be ascribed all perfection and majesty .

The thanks after Allah must be to my virtuous teacher Dr Rawia Abdelgani Elobaid. Who supervised this research and guide me in patience until the results of this research are obtained .

Thanks my teacher Dr. Ali Suleiman .

I wish to express my thanks to the Sudan University of science & technology , department of physics .

My gratitude is sent to Dr. Abdalsakhi (Neelien university , department of Laser physics).

My thanks , also must be sent to all my friends and classmates for any support that make me completed this research.

Abstract

A thin film is a layer of material ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. In this thesis three types of thin films of silicon dioxide were prepared then doped using three different samples Iodine, Coumarin500 and Rhodamine B. The preparation was done under Electrical Deposition Techniques (E D T) (Spin Coating) using power supply mating 2 Volts and current of 0.03A, at room temperature.

The optical properties such as absorption and absorption coefficient, transmission, reflection, refractive index, excitation coefficient, energy gap and dielectric constant (real and imaginary). Was studied using UV Spectrometer with wavelength in the range 220 to 450 nm.

The study found that the silicon dioxide doped with Rhodamine B is highest in all optical properties studied, except transmission and Energy Gap, while the Coumarin500 has a wide range of wavelengths for all optical properties studied, ranging from 268 to 418 nm. In addition, the doped sample with iodine has a negative reflectivity, while the doped sample with Coumarin500 and Rhodamine B are positively reflectivity.

المستخلص

الأفلام الرقيقة هي طبقة من المادة بسمك يتراوح من جزء من النانومتر وحتى عدة مايكرومترات . في هذا البحث تم تحضير ثلاثة أفلام رقيقة من ثاني أكسيد السليكون المطعم بثلاثة عينات مختلفة من اليود و الكومرين 500 والرودمين بي , حيث استخدمت تقنية الترسيب الكهربي (الطلاء الدوار) بجهد 2 فولط وتيار شدته 0.03 أمبير وعند درجة حرارة الغرفة , ثم درست الخصائص البصرية مثل طيف الإمتصاص ومعامل الإمتصاص والنفاذية والإنعكاسية بالإضافة إلى دراسة فجوة الطاقة و معامل الإنكسار ومعامل الخمود وكذلك ثابتي العزل (الحقيقي والخيالي). درست بإستخدام جهاز مطياف الأشعة فوق البنفسجية (UV Spectrometer) في مدى طول موجي بين 220 إلى 450 نانومتر .

ووجد أن ثاني أكسيد السليكون المطعم بالرودمين بي له أعلى قيمة في كل الخصائص البصرية المدروسة عدا النفاذية وفجوة الطاقة, بينما الكومرين 500 له نطاق واسع من الأطوال الموجية لكل الخصائص المدروسة يمتد من 268 وحتى 418 نانومتر , وكذلك أن تطعيم ثاني أكسيد السليكون باليود له إنعكاسية سالبة , بينما التطعيم بالكومرين 500 والرودمين بي له إنعكاسية موجبة .

Contents

List of Table

lists of figures

Chapter One

Introduction

1.1 Introduction

This work is dedicated to the study silicon dioxide (SiO_2) doped by some compounds such as Iodine, Coumarin500 and Rhodamine B in Nano-scale size, this matter was intensively studied in the last years because such structures exhibit peculiar properties with make them attractive for application in optical and biological sensors and optoelectronics. The properties of material can be different on a nano-scale for two main reasons[1]. First nano-materials have, relatively, a larger surface Area than the same mass of material produced in a large form, this can make materials more chemically reactive (in some cases material that are inert in their larger form are reactive when produced in their nano-scale form). and affected their strength or electrical properties. Second below 50 nm, the laws of classical physics give way to quantum effects provoking optical, electrical, and magnetic behaviors different from those of the same material. At a large scale, these effects can give materials very useful physical properties such as exceptional electrical conduction or resistance, or a high capacity for storing or transfer heat, and can even modify biological properties, with silver for example becoming a bactericide on a Nano-scale [1,2].

1.2 The Problem

The thin films for its wide range application due to it structures which exhibit peculiar properties that make them attractive for application in optical and biological sensors and optoelectronics.

1.3 The Aim of The Research

The Optical Properties of Silicon Dioxide Doped By Iodine, Coumarin500 and Rhadomine B.

1.4 Methodology

Preparation of thin films from silicon dioxide then doped by iodine , coumarin500 ($C_9H_6O_2$) and Rhodamine B. UV technique applied .

1.5 Literature Review

1. Vladislav G. Il'ves, Michael G. Zuev submitted (Properties of Silicon Dioxide Amorphous Nano powder Produced by Pulsed Electron Beam Evaporation)[3] SiO_2 amorphous Nano powder (NP) is produced with the specific surface area of $154 m^2/g$ by means of evaporation by a pulsed electron beam aimed at Aerosil 90 pyrogenic amorphous NP (90m2/g) as a target. SiO_2 NP nanoparticles showed improved magnetic, thermal, and optical properties in comparison to Aerosil 90 NP. Possible reasons of emergence of d0 ferromagnetism at the room temperature in SiO_2 amorphous NP are discussed. Photo luminescent and cathode luminescent properties of the SiO_2 NP were investigated.

2. Yong Yang, Masae Takahashi, Hiroshi Abe and Yoshiyuki Kawazoe submitted (Structural, Electronic and Optical Properties of the Al_2O_3 Doped SiO_2: First Principles Calculations)[4]. The doping effects of Al_2O_3 on SiO_2 (cristobalite) have been studied by first principles calculations, with emphasis on the structural, electronic and optical properties. Compared to pure SiO_2 crystal, the electronic density of states (DOS) of the Al_2O_3 doped SiO_2 show significant changes. The electron energy states corresponding to the newly emerged sharp DOS peaks are found to exhibit localized characteristics, which are mainly attributed to the unsaturatedly bonded 2p orbital's of O atoms in the −[Al-O-Al]− linkages. The optical properties of the Al_2O_3 doped SiO_2 are studied by calculating the frequency-dependent dielectric functions. The electric dipole moment induced by the electron states near the top of the valence band is found to have significant effect on the optical absorption spectrum.

3. Fozia Haque Submitted (syntheses and spectroscopic characterization of coumarin440 dye doped silica gel rods)[5]. We have studied silica gel by sol–gel technique for the preparation of new dye-laser materials. Silica gel rods with dimension 50× 10 mm 2 have been prepared successfully without breaking. It shows high transparency and good mechanical strength. Tetraethylortho silicate (TEOS), form amide in molar ratio (0.25: 0.70), 80 ml ethanol, 20 ml dim ethyl form amide (DMF), 10 ml water, hydrochloric acid as a catalyst (at pH 6), and 0.5 ml silicone defaming agent/surfactant have been used. The synthesis has been carried out

4. S. S. Nekrashevich and V. A. Gritsenko Submitted thesis (Electronic Structure of Silicon Dioxide (A Review))[6]. Silicon dioxide amorphous films are the key insulators in silicon integrated circuits. The physical properties of silicon dioxide are determined by the electronic structure of this material. The currently avail -able information on the electronic structure of silicon dioxide has been systematized.

1.6 Presentation of the Thesis

Chapter one Introduction, chapter two Background Theory, chapter three materials and methods and chapter four Results and Discussion.

Chapter Tow

Background Theory

2.1 Nanotechnology

Nanotechnology is defined as the study and use of structures between 1 nanometers and 100 nanometers in size (nanometer is one thousand millionth of meter). Nano-materials is typically between 1 and 100 nanometers in size , were the materials of this size display unusual physical and chemical properties, this profoundly different properties and due to an increase in surface area compared to volume as particles get smaller. It has been observed that the electronic, conductive, interactive, melting, and mechanical properties of the material change all when the size of the particles is less than a critical value of size[2,7]. The dependence of the material behavior on its size enables us to control the engineering of its properties, therefore, this concept has great technical effects, including wide technical fields, including the production of lightly and strong materials. And can be define Nano-science as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scale, where properties differ significantly from those at large scale, and nanotechnologies as the design, structure, devices and system by controlling shape and size at the nanometer scale[8]. Nanotechnology is one of the leading scientific fields today since it combines knowledge from the fields of Physics, Chemistry, Biology, Medicine, Informatics, and Engineering. It is an emerging technological field with great potential to lead in great breakthroughs that can be applied in real life. Novel Nano and biomaterials, and Nano devices are fabricated and controlled by nanotechnology tools and techniques, which investigate and tune the properties, responses, and functions of living and non-living matter, at sizes below100 nm. The application and use of Nano materials in electronic and mechanical devices, in optical and magnetic components, quantum computing, tissue engineering, and other biotechnologies, with smallest features, widths well below 100 nm, are the economically most important parts of the nanotechnology nowadays and presumably in the near future. The number of Nano products is rapidly growing since more and more Nano engineered materials are reaching the global market The continuous revolution in nanotechnology will result in the fabrication of Nano materials with properties and functionalities which are going to have positive changes in the lives of our citizens, be it in health, environment, electronics or any other field. In the energy generation challenge where the conventional fuel resources cannot remain the dominant energy source, taking into account the increasing consumption demand and the CO_2 emissions alternative renewable energy sources based on new technologies have to be promoted. Innovative solar cell technologies that utilize nanostructure materials and composite systems such as organic photovoltaic's offer great technological potential due to their attractive properties such as the potential of large-scale and low-cost roll-to-roll manufacturing processes the advances in Nano materials necessitate parallel progress of the Nano metrology tools and techniques to characterize and manipulate nanostructures. Revolutionary new approaches in Nano metrology[8,9].

2.2 History of Nanotechnology

The presence of nanoscale device and nanoscale structure is not now, since their existence dates back to earth age. Living cells are known to produce some very smell device that reach the limits of the nanometer, live cells are an important example of natural nanotechnology, cells are a repository of a large number of biological machines the size of nanotechnology. But the actual history of nanotechnology dates back to 1957. In 1957 the physicist Richard said that the matter with a few atoms behaves differently than when they are of significant size. He also pointed out that it is possible to develop a method to independently move atoms and molecules to reach the desired size. At these levels, many physical concepts change. In 1976 the Palestinian scientist Munir Naifah introduced a method of laser called (resonance ionization) to detect individual atoms and measure them with the highest levels of accuracy and control monitoring one atoms among millions of atoms and revealing their identity for the first time in history. Its method is to excite and Ionize the atoms with a specific color laser and then sense the charge. Thus scientist can move one atom and manipulate it and rearrange atoms of matter as they want. In 2000 the same scientist Munir Naifah discovered and manufactured a family of the smallest silicon granules of one nanometer diameter, consisting of 29 atoms of silicon, surface in the form of carbon fluorine but inside it is not empty but mediated by one single atom, when exposed to ultraviolet light, they give different colors according to their diameter ranging from blue, green and red[9].

2.3 Characteristic of Nanotechnology Characterization

- Scientist consider that silicon is semiconductive material, but the fact that silicon layers with a thickness of less 100 nanometers is conducted to electricity.
- This feature applies to all semiconductors when minimized to the size nanostructures.
- Silicon in its normal stat, is not suitable for lasers, but with nanotechnology, researchers can dig billions of holes in silicon and rearrange its structure to produce laser. This discovered is very important because its brings the possibility consisting laser with electronic device into a single silicon chip that improves performance and low cost[1].

2.4 Nanotechnology Applications

Nanotechnology can be used to create fabrics with superior performance without compromising the look, feel or comfort of the fabric. For instance, nonmaterial's can be added to the fabric and make them stain resistant. Using Nano particles in the manufacture of solar cells is beneficial because, They can reduce manufacturing costs by using a low temperature process instead of the high temperature vacuum deposition process typically used to produce conventional cells made with crystalline semiconductor material. They can reduce installation costs by producing flexible rolls instead of rigid crystalline panels. Currently available nanotechnology solar cells are not as efficient as traditional ones, however their lower cost offsets this. In the long term nanotechnology versions should both be lower cost and, using quantum dots, should be able to reach higher efficiency levels than conventional ones. Nano -structured devices have the potential to serve as the basis for next-generation energy systems that make use of densely packed interfaces and thin films. Researchers have developed metal-insulator-metal Nano capacitors It is possible to accommodate one million such tiny capacitors on one square centimeter area. The use of such capacitors in battery and other energy storage devices may increase the efficiency and capacity of such devices enormously [10]. Also Pancreatic cancer has a devastatingly low survival rate (less than 5 percent after 5 years) because it is usually diagnosed at an advanced stage. Scientists have created tools for the early diagnosis of pancreatic cancer by attaching a molecule that binds specifically to pancreatic cancer cells to iron oxide Nano particles that are clearly visible under magnetic resonance imaging (MRI)[10].

2.5 Silicon Dioxide SiO_2

It dates back to millions of years when Silicon dioxide was formed, nearly back to the times after earth was formed. At that time the earliest forms of life made their skeletons from silicon dioxide, plants were using silicon dioxide for support structures. Berzelius (1779-1848) "discovered" SiO_2 in 1824. Later on, on the timeline of earth when existence of human being starts the mighty Romans used silicon dioxide in the form of sand to strengthen the invention of concrete. The upper class Romans utilized quartz which is another form silicon dioxide for gemstones in jeweler. During the same period in Asia, Hindu monks used to spent large portions of their life using silicon dioxide in the form of sand to make designs and destroy them and then make another design which still continued till date. Glass which is another form of silica was first invented by the Venetians of Italy. Glass is mainly made of silicon dioxide with other compounds such as Na_2O, Ca O, and Al_2O_3. Silicon dioxide has played a significant role in the world's history and will continue to throughout the ages. It is believed by many people that in the future the majority of life forms will no longer be based on carbon but on silicon[11]. Silicon Dioxide, whose common name is silica, is a white or transparent, crystalline and odorless solid. It belongs to group IV of the chemical family called metal oxides. It is a very stable compound, and only reacts with hydrofluoric acid. Silicon dioxide is an acidic oxide and acidic nature is due to the production of hydrogen ions when it is in water. Silicon dioxide transmits visible and ultraviolet light. Silicon Dioxide comes in many different geometrical patterns. Till date near about 35 crystalline shapes have been observed which results in different density of each group of atoms. Another crystalline form of silicon dioxide known as ketite was produced during the first atomic bomb test run that was dropped in New Mexico[11,12]. Quartz one of the most common shapes can transform when silicon dioxide is heated over 867 ^{o} C. Silicon dioxide is held together by double, covalent bonds. Silicon dioxide is one of the most abundant compounds on the planet earth and has many different uses. Thus world without glasses will be unimaginable. Silicon can be easily found in the earth's crust in crystalline form or in amorphous powder form. 75% of the earth's crust is made up of Silicon and oxygen together. Sand is Silicon Dioxide only and that makes sandy areas such as the beach and desserts which make a good resource for silicon dioxide. Silicon dioxide can be found in the earth crust in quartz form also. Silicon dioxide is a compound of many uses and has been for many years. Due to its abundance it is used commercially as a resource for pure silicon. Large furnaces are used to heat silicon dioxide, they remove oxygen and leave pure silicon behind. The modern electronics world greatly depends on silicon dioxide for the manufacture of semiconductors, wire insulation, and fiber optic cables. Since quartz (SiO_2) has piezoelectric properties this makes silicon an ever more-valuable compound to modern electronics. This property of quartz allows for radio and TV stations to transmit, stabilize, and receive signals. Sonar also uses piezoelectric property to detect vibrations. Wrist watches also use quartz to help keep accurate time. The oil industry today uses silicon dioxide gel to help refine crude oil into usable fuel such as gasoline. Silicon dioxide also finds usage in field of engineering. It is also used in glasses for windows, metal alloys, pipe flux, metal alloys, concrete, sand for foundations, sealants, sandblasting, and many more applications. Silicon dioxide (Silica) is one of the most commonly encountered substances in both daily life and in electronics manufacturing. Crystalline silicon dioxide has several forms such as quartz, cristobalite and tridymite. Today, the modern electronics world greatly depends on silicon dioxide for the manufacture of semiconductors, wire insulation, and fiber optic cables. Its high melting temperature and chemical stability make it perfect for use in insulating wires[13].

Sand (Silica) one of the most common minerals in the earth, main component in common glass. Has many forms including three main crystalline varieties, quartz, tridymite, and cristobalite. Silica can also exist can non-crystalline form as silica glass or vitreous silica, and referred to as amorphous silica and glass silica, there are four basic type of commercial silica glass[14]:

- Type I is produced by electric melting of normal quartz crystal in vacuum or in an inert gas at low pressure.
- Type II is produced from quartz crystal powder by flame fusion.
- Type III is synthetic and produced by hydrolyzation of SiCl4 when sprayed into an oxygen-hydrogen flame.
- Type IV is also synthetic and produced from $SIcl_4$ in a water vapor-free plasma flame.

Each type of silica glass has its own impurity level and optical properties for example, type I silica glasses tended to contain metallic impurities, on the other hand type III and IV are much purer than type I, and feature greater ultraviolet transmission, however type III silica glasses have (in general) higher water contend and infrared IR transmission is limited by strong water absorption backs at wavelengths around 2.2 and 2.7 micrometer. Type IV is similar to type III but contains less water and those terms are often used interchangeably because of its favorable physical, chemical, and optical characteristics[15].

2.6 Silicon Dioxide Applications

- As laboratory glass ware.
- In optics as lenses.
- For lighting and infrared heating.
- In telecommunication, as fiber optics.
- In micro and optoelectronics, as dielectric insulator waveguide, photonic crystal fibers, or projection masks for photolithography.
- In thermal protection systems, as fibrous thermal insulation[16].

In all these applications, optical properties are essential in predicting and optimizing the optical and thermal radiation performances of this material, silica fiber optics, for example, are used in the near infrared a round 1.31 and 1.55 micrometer due to their low optical attenuation and optical dispersion, in lens design, one often needs to fit and interpolate refractive index data which are reported or measured at discrete wavelengths over a certain spectral regions, on the other hand, astronomers and atmospheric scientist are interested in optical properties of interstellar an atmospheric silica particles in the mid-and far-infrared region of the spectrum .The complex refractive index m_{λ} of silica glass wavelength λ is defined as[17]:

$m_{□} = n_{□} + ik_{□}$

(2.1)

Were $n_{□}$ is the refractive index, and $k_{□}$ is absorption index. The wavelength ƛ is related to other quantities such as frequency v and wave number η according to

$□ = c_{□}/v = 1/□$

(2.2)

Were $c_{□}$ is speed of light at wavelength ƛ in vacuum, therefore, the refractive and absorption indices can also be expressed as functions of frequency and denoted by $n_{□}$ and $k_{□}$ or as function of wave number and denoted by $n_{□}$, and $k_{□}$. The experimental data for the refractive and absorption index vary in precision depending on the measurement techniques used and on the approximation made in retrieving the intrinsic optical properties. One should also keep in mind that these optical properties may be sensitive to the presence of impurities, crystallinity, point defects, inclusions, bubbles, wavelength, temperature, and the glass manufacturing process [18].

2.7 Silicon Dioxide Structure

Tetrahedral arrangement with one silica bonded to four oxygen atoms, most oxygen atoms will be bonded to two silicon atoms, so that two tetrahedral are joined at a corner. The orientation can be random, leading to an amorphous structure, and some oxygen atoms will be bonded to only one silicon atom. And he is formed when silicon is exposed to the oxygen in the atmosphere, if you look at the atomic model of silicon dioxide you'll see that the four oxygen atoms are located far apart from the silicon atom at the center[21].

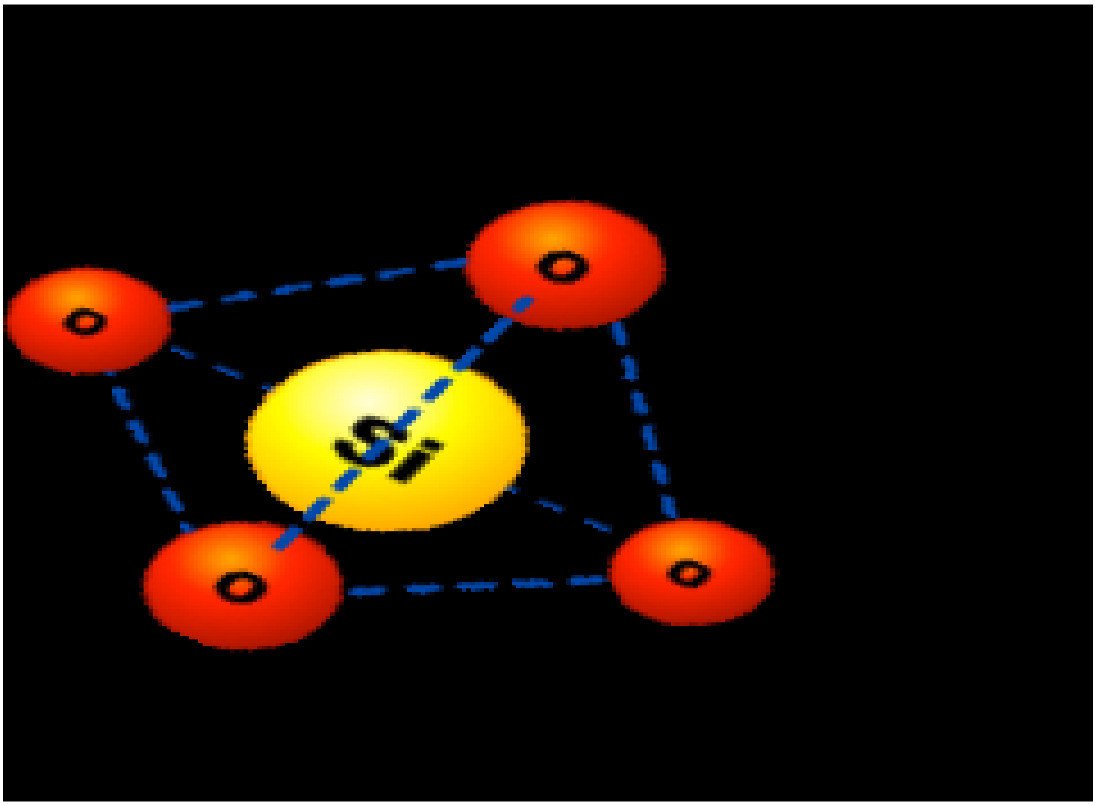


Figure (2.1) SiO_2 **(**one silicon atoms bonded to four oxygen atoms)

2.8 Oxidation of Silicon

There are several ways to form a layer of silicon dioxide SiO_2 on the surface of silicon, The two per-dominate method are[20]:

- Thermal oxidation of silicon – react silicon from the wafer with oxygen to created oxide.
- Deposition of a thin film by chemical vapor deposition.

Thermal oxidation is a simple process – introduce an oxidizing atmosphere to the surface of the silicon with sufficient temperature to make the oxidation rate practical, there are two commonly used variants[21]:

Pure oxygen : $Si + O_2 \Rightarrow SiO_2$ (dry oxidation) (2.3)

Water vapor : $Si + 2H_2O \Rightarrow SiO_2 + 2H$ (wet oxidation) (2.4)

The typical oxide thickness range from a few nanometer to about 1 micron.

2.9 Some optical Properties of Silicon Dioxide

2.9.1 Refractive Index $n_{□}$

Can use Snell's low and can be estimated by[22]

$$n_{□} = \frac{c}{v} \qquad (2.5)$$

where C is speed light in vacuum, and v is speed light in sample. And can be measured the refractive index by:

$$n_0 = \left[\frac{(1+R)^2}{(1-R)^2} - (k_0 - 1)\right]^{1/2} + \frac{(1+R)}{(1-R)} \qquad (2.6)$$

Where k_0 is extinction index.

2.9.2 Energy Gap

The optical energy gap is defined as the least energy needed to transfer the electron from top of the valance pack to the bottom of the conduction back.

The energy gap is one of most important constant is semi conductor physics, the use of semi conductors in optical applications such as solar cells, photovoltaic cells, reagents, photovoltaic diodes, and the coating processes is based on this constant, often chosen the materials that are energy gap is approximate the energy of photons within a portion of the electromagnetic spectrum, and according the need to control as much as absorbs, or transmit, or is reflected from photons falling on the film[22].

$$E_g = e\left(\frac{-\Delta E}{KT}\right) \quad (2.7)$$

E_g IS Energy Gap, and ΔE is energy difference, K is Boltzmann factor, T temperature.

$$(h\upsilon - E_g)\ B_0 = \alpha h\upsilon \quad (2.8)$$

E_g is optical energy gap, B_0 is constant independent on nature material, $h\upsilon$ is photon energy.

2.9.3 Absorptive Spectrum and Absorption Coefficient

The absorptive spectrum results from the loss of energy resulting from the reaction between the light and the charge contained in the material. When an optical beam falls on a film and its intensity is I_0, the resulting beam is the intensity I, according to Lambert low[24]

$$I = I_0 \exp(-\alpha d) \quad (2.9)$$

Were α is absorption coefficient is defined as the ratio of decrease in the radiation energy output, or intensity relative to the distance of the wave direction within the center. And d is film thickness

$$\alpha = 2.303A/d \quad (2.10)$$

$$A = \log I/T \tag{2.11}$$

Where total the absorption coefficient and reflective index and transmission index is equal one. Absorption is the property of the material of transferring energy from the photons to its atoms and molecules. The ratio of the energy transferred to the matter from the incident light to the total incident energy is called Absorptance (A)[22,25].

2.9.4 Transmission

Is the ratio between the photovoltaic energy that is run out from the surface to the energy falling on the surface

$$T = I/I_0 \tag{2.12}$$

2.9.5 Reflective

Is the ratio between the reflective energy from the surface and the total energy falling on the surface[22]

$$R = 1 - (A + T) \tag{2.13}$$

And defined the reflective index Is the ratio between the reflective radiation intensity from the surface to falling radiation intensity on the surface.

2.9.6 Extinction Coefficient

$$k = \frac{\alpha\square}{4\pi}$$

(2.14)

2.9.7 Dielectric Constant Calculation

The interaction between light and medium charge is due to the absorption of energy in the material and then to the polarization of the charges of that medium, this polarization is usually described by the electrical dielectric constant of that medium. As divided to two type:

2.9.7.1 Real Dielectric Constant

$$€_1 = n^2 - k^2 \quad (2.15)$$

2.9.7.2 Imaginary Dielectric Constant

$$€_2 = 2nk \quad (2.16)$$

2.10 Important Properties of Silicon Dioxide SiO_2

Table(1) shows some important properties of silicon dioxide, it can be noted that oxide grown in a dry atmosphere have a higher density, which implies less impurities and a better quality oxide than when grown in a wet a temperature, thermal expansion refers to the oxides volume expansion or shrinkage, when exposed to arrange of temperature, for oxides, the thermal expansion coefficient is very low, meaning it does not exert much stress and strain on other materials which are in contact with it, Young's modulus and Poisson's ratio measure the oxides stiffness and its negative ratio of transverse to axial strain, respectively which are important measures of a materials mechanical stability, the thermal conductivity which varies for thin sputtered (1.1 w/m .k), thin thermally grown (1.3 w/m .k) and bluk (1.4 w/m .k) oxide is an important parameter with affects power during operation, it is also found that the thermal conductivity of oxides changes depending on the oxide thickness the high dielectric strength shows the stability of SiO_2 under high electric fields, suggesting that the oxides film is very suitable for dielectric isolation[25].

Table (2.1) important properties of SiO_2 [23,25]

1	Crystal structure	Amorphous
2	Chemical formula	SiO_2
3	Molar mass	60.08 g/mol
4	Density (thermal dry/wet)	2.27 / 2.18 g/cm3
5	Specific heat	1.0 g/kg
6	Melting point	1700 c
7	boiling point	2950 c
8	Thermal expansion coefficient	5.6 $\times 10^{-7}$/k
9	Young's modulus	6.6 $\times 10^{10}$N/m2
10	Poisson's ratio	0.17
11	Thermal conductivity	1.1 - 1.4 w/m .k
12	Relative dielectric constant	3.7 - 3.9
13	Energy gap	3.9 ev
14	Dc resistivity	$10^{17}\approx$

Table (2.2) some optical properties for silicon dioxide SiO_2[22,25]

1	Transmission range T	0.18 to 2.2 (3µm for IR glass)
2	Refractive index R	1.47 at 4 µ m
3	reflection index r	7.0 % at 0.4 µ m (2 surface)
4	Absorption Coefficient A	10×10^{-6} /cm at 1 µ m

Chapter Three

Material and Methods

3.1 Introduction

A thin film is a layer of material ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. The controlled synthesis of materials as thin films (a process referred to as deposition) is a fundamental step in many applications. A familiar example is the household mirror, which typically has a thin metal coating on the back of a sheet of glass to form a reflective interface. The process of silvering was once commonly used to produce mirrors, while more recently the metal layer is deposited using techniques such as sputtering. Advances in thin film deposition techniques during the 20th century have enabled a wide range of technological breakthroughs in areas such as magnetic recording media, electronic semiconductor devices, LEDs, optical coatings (such as antireflective coatings), hard coatings on cutting tools, and for both energy generation (e.g. thin-film solar cells) and storage (thin-film batteries). It is also being applied to pharmaceuticals, via thin-film drug delivery. A stack of thin films is called a multilayer. In addition to their applied interest, thin films play an important role in the development and study of materials with new and unique properties. Examples include multiferroic materials, and super lattices that allow the study of quantum confinement by creating two-dimensional electron states[26].

3.2 materials

In this thesis some materials was prepared in addition to the silicon dioxide as deponents material.

3.2.1 Iodine

Iodine is a chemical element with symbol I and atomic number 53. The heaviest of the stable halogens, it exists as a lustrous, purple-black metallic solid at standard conditions that sublimes readily to form a violet gas. Iodine is the fourth halogen, being a member of group 17 in the periodic table, below fluorine, chlorine, and bromine; it is the heaviest stable member of its group[27]. Humans need iodine to make thyroid hormones. These hormones are produced by the thyroid gland, a butterfly-shaped structure in the front part of the neck consisting of two "lobes" on either side of the windpipe connected by a narrow bridge called the isthmus. After manufacture in the thyroid gland, thyroid hormones travel in the blood and control many chemical processes in different parts of the body. These hormones are essential for normal development and function of the brain and nervous system, and for maintenance of body heat and energy[28].

3.2.2 Coumarin500 ($c_9h_6o_2$)

Coumarin500 is a fragrant organic chemical compound in the benzopyrone chemical class, although it may also be seen as a subclass of lactones. It is a natural substance found in many plants, and a colorless crystalline substance in its standard state. It has a sweet odor, Coumarin500 has clinical medical value by itself[29] .

3.2.3 Rhodamine B $C_{28}H_{31}ClN_2O_3$

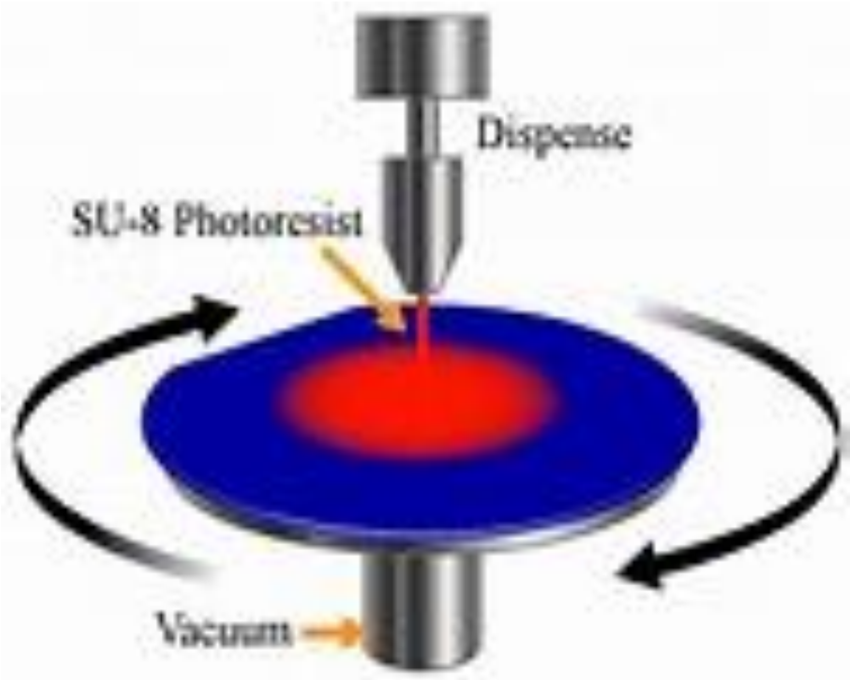
Rhodamine B is a chemical compound and a dye. It is often used as a tracer dye within water to determine the rate and direction of flow and transport. Rhodamine B dyes are used extensively in biotechnology applications such as fluorescence microscopy, flow cytometry, fluorescence correlation spectroscopy Rhodamine B dyes are used as the active medium of tunable laser radiation in the visible region of the light spectrum. and They appear red to violet in color. The molecular formula of Rhodamine B (RB) is $C_{28}H_{31}ClN_2O_3$ with molecular weight of 479.02 gm/mol. It is often used as a tracer dye in water to determine the rate and direction of flow and transport[30].

3.3 Methods

Three samples was prepared from silicon dioxide and doped by Iodine, Coumarin500 and Rhodamine B by Spin Coating method, using Electrical Deposition Technical, with power supply of 2 volt and current 0.03 A at room temperature. Then UV spectrometer used to study optical properties.

3.3.1 Spin Coating

Spin coating is one of the most common techniques for applying thin films to substrates. It is used in a wide variety of industries and technology sectors. The advantage of spin coating is its ability to quickly and easily produce very uniform films, ranging from a few Nanometers to a few microns in thickness . The use of spin coating in organic electronics and nanotechnology is widespread and has built upon many of the techniques used in other semiconductor industries. It also has some differences due to the relatively thin films and high uniformity required for effective device preparation, as well as the need for self-assembly and organization to occur during the casting process[31].



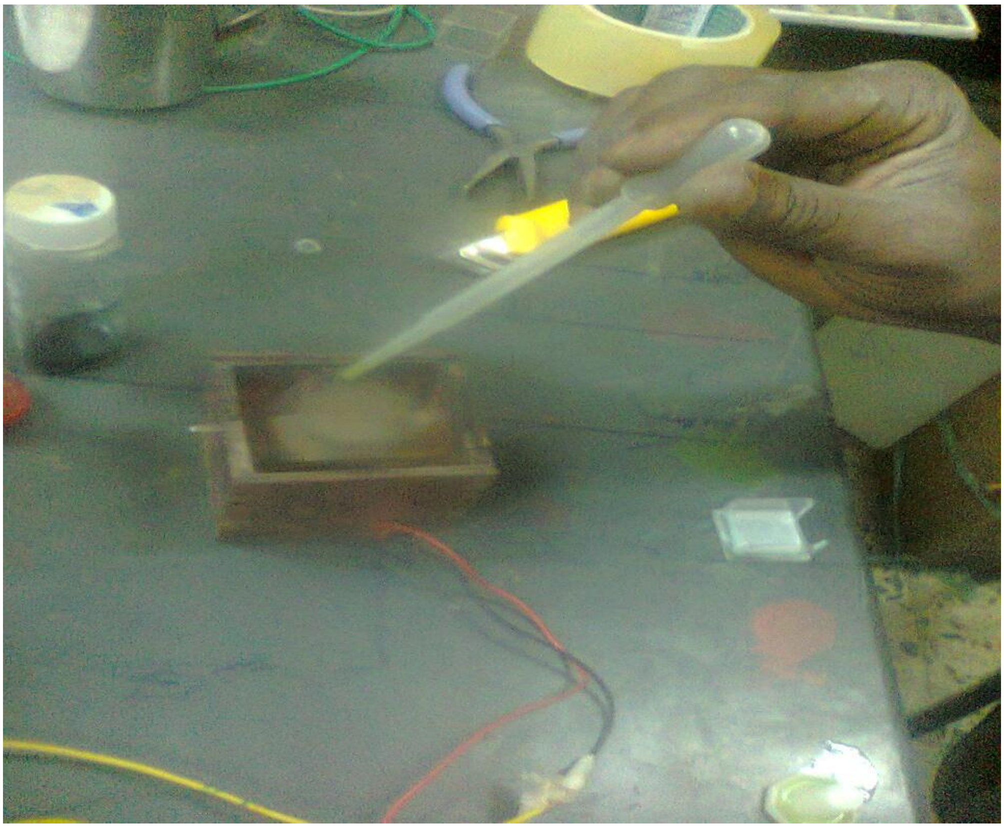


Figure (3.1) Spin Coating Configuration

3.3.2 Ultraviolet Spectrometer (U V)

Ultraviolet and visible spectrometers have been in general use for the last 35 years and over this period have become the most important analytical instrument in the modern day laboratory. In many applications other techniques could be employed but none rival UV-Visible spectrometry for its simplicity, versatility, speed, accuracy and cost-effectiveness. This description outlines the basic principles for those new to UV-Visible spectrometry[32].

Figure (3.2) UV Spectrometer

Chapter four

Result and discussion

4.1 Results

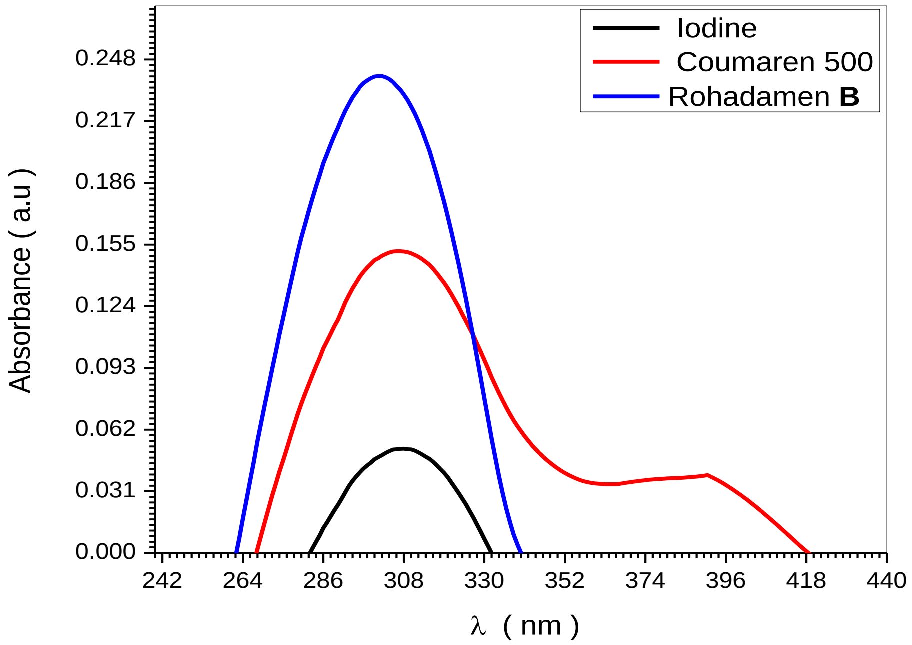


Figure (4.1) relation between absorption and wavelength for three samples.

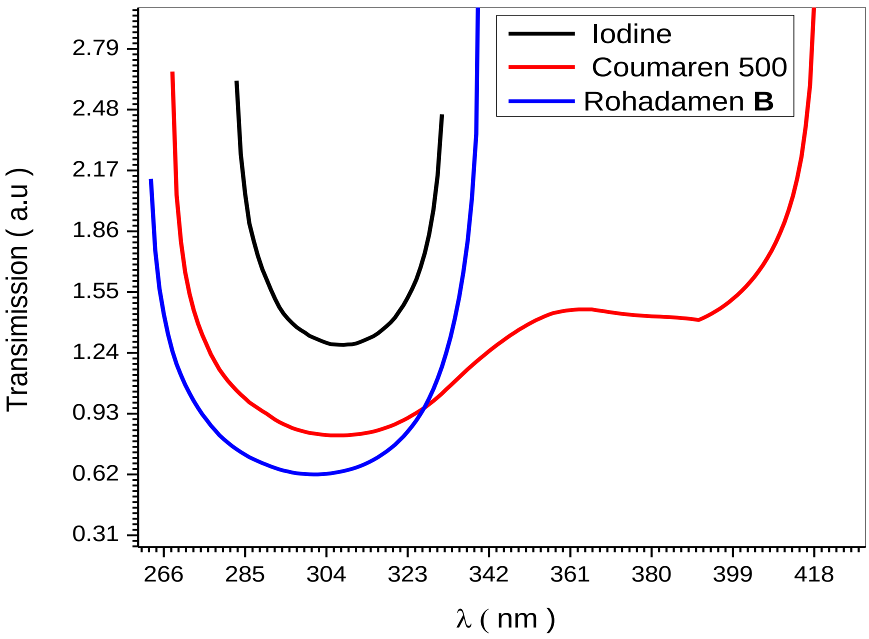


Figure (4.2) relation between transmission and wavelength for three samples.

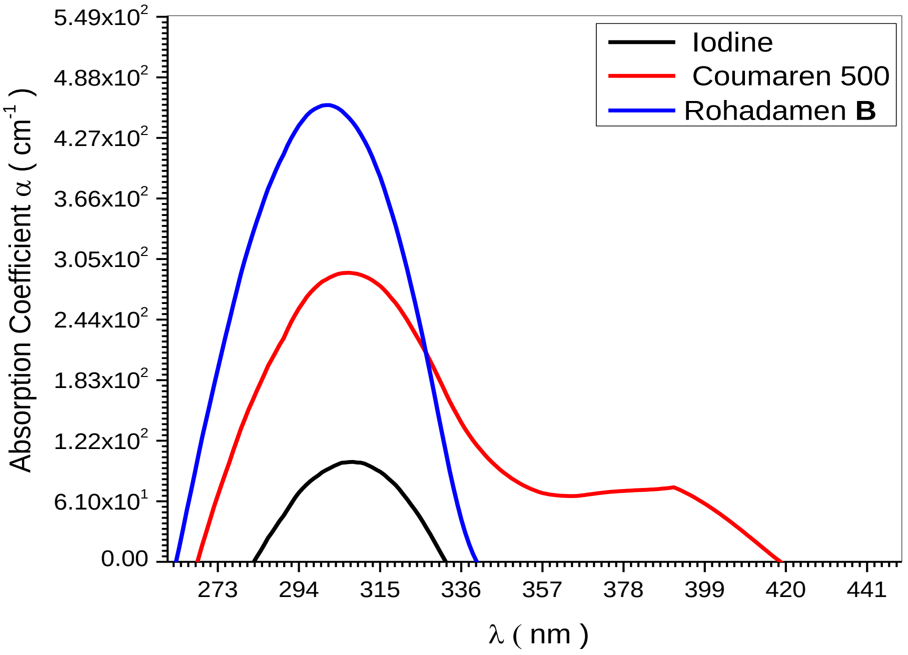


Figure (4.3) relation between absorption coefficient and wavelength for three samples.

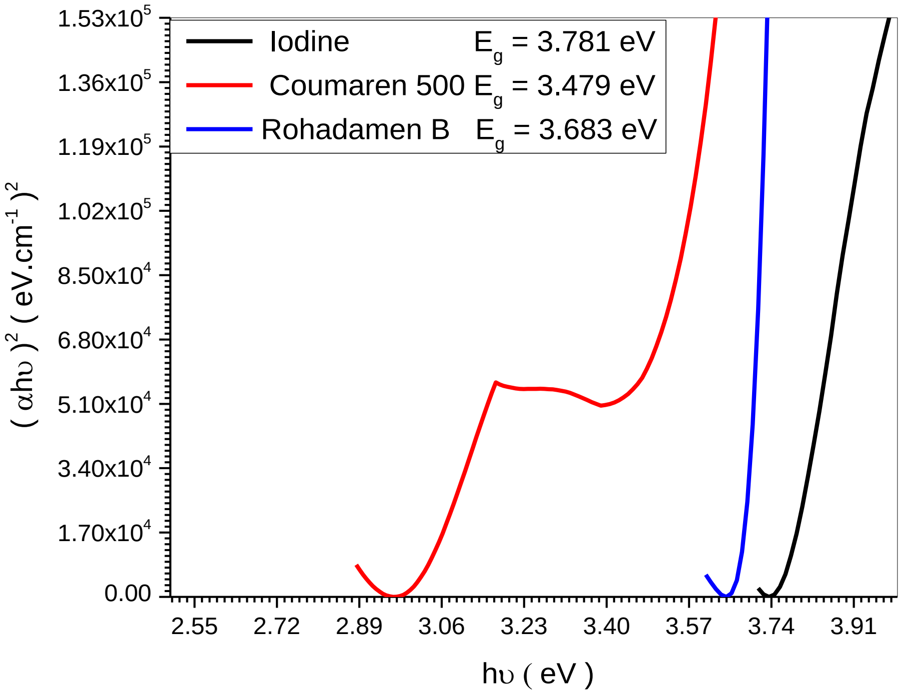


Figure (4.4) relation between band energy gap and photon energy for three samples.

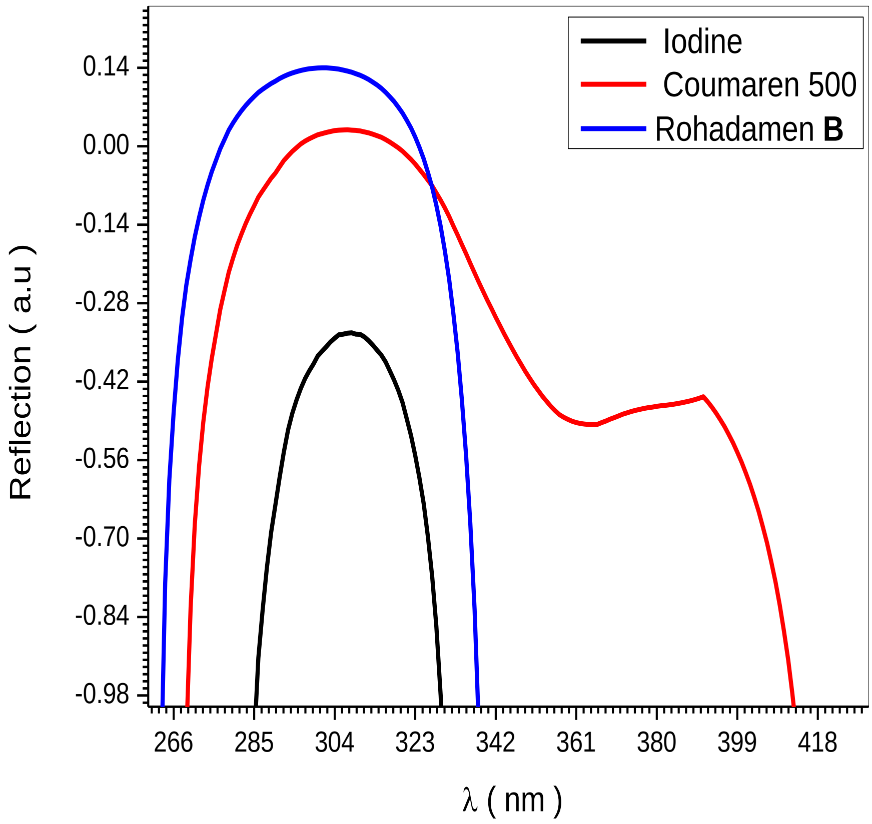


Figure (4.5) relation between reflection and wavelength for three samples.

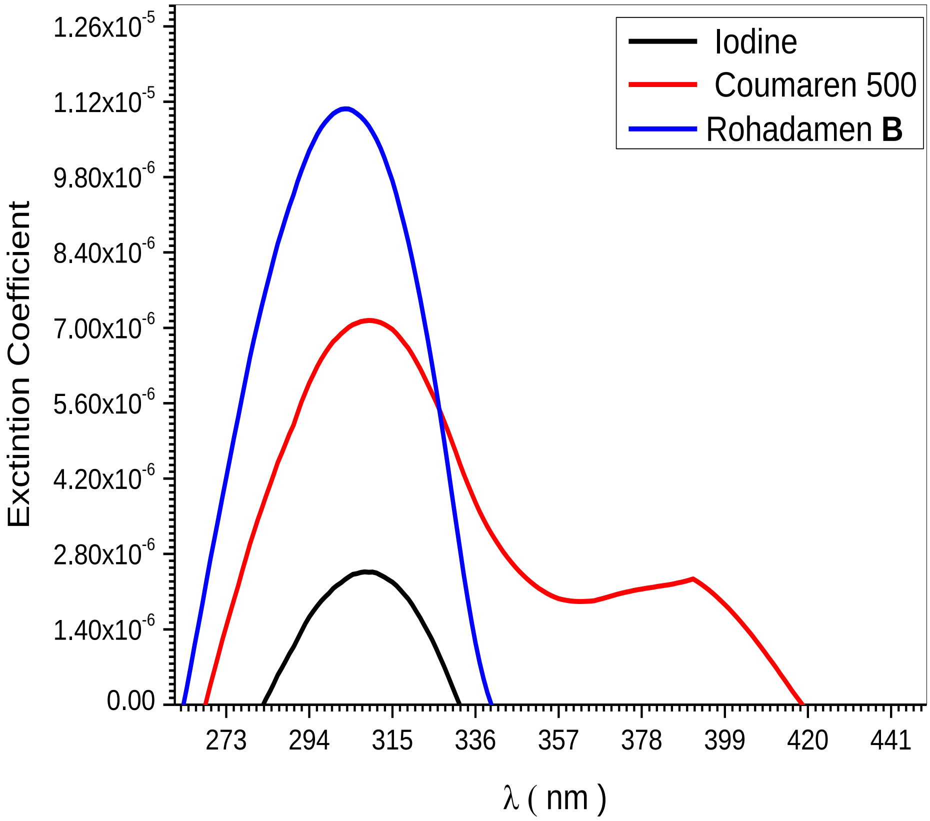


Figure (4.6) relation between Excitation coefficient and wavelength for three samples.

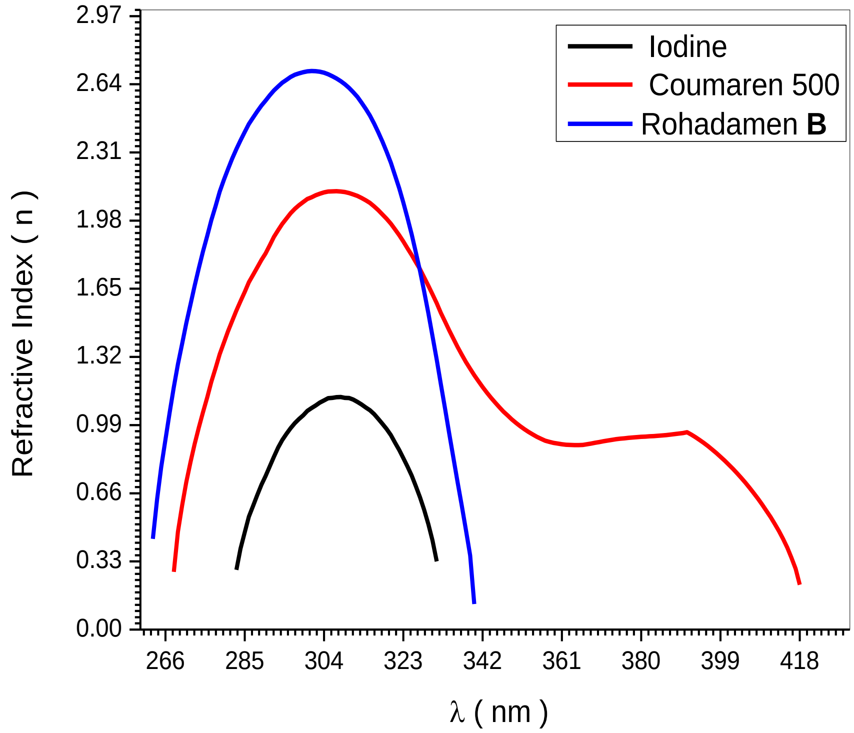


Figure (4.7) relation between refractive index and wavelength for three samples.

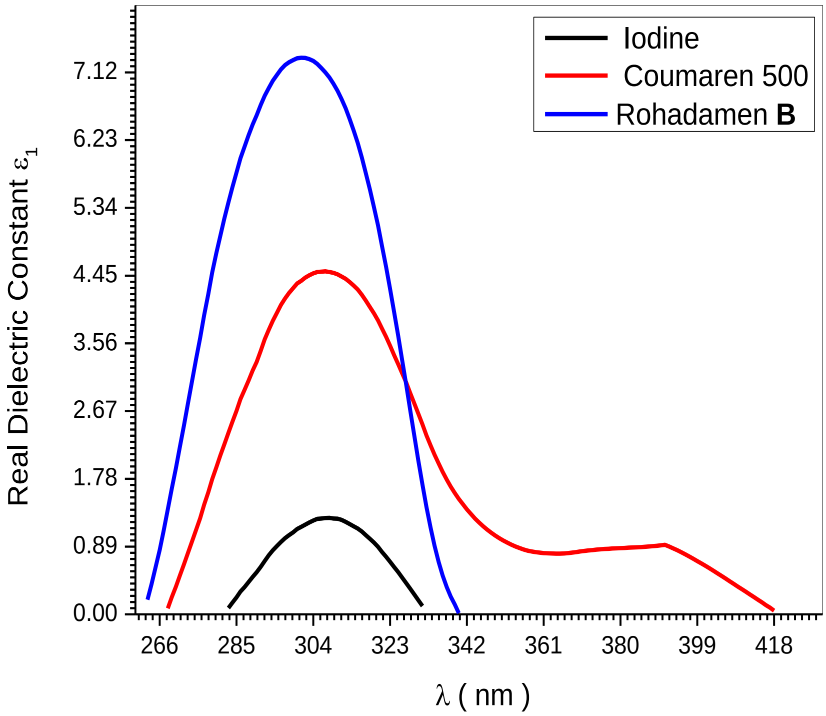


Figure (4.8) relation between real dielectric constant and wavelength for three samples.

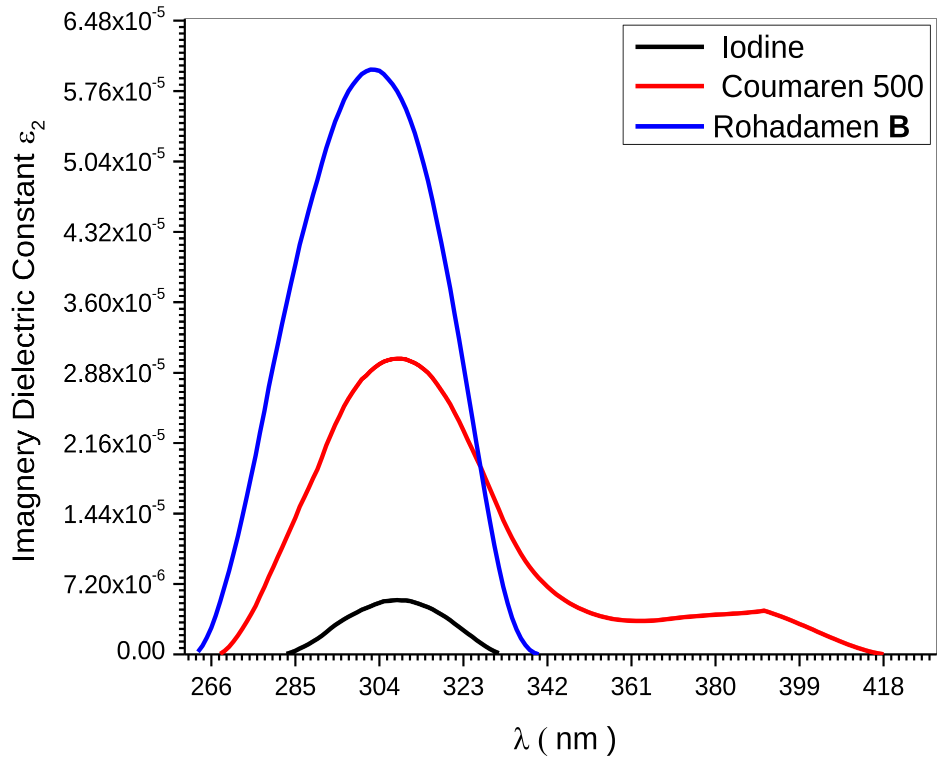


Figure (4.9) relation between imaginary dielectric constant and wavelength for three samples.

4.2 Discussion and Conclusion

From fig (4.1) it is clear that the relation between absorption and wavelength for the different samples was different small peak of absorption in iodine, while maximum absorption with Rhodamine B. while in transmission curve fig (4.2) Iodine has maximum transmittance it was observed also coumarin500 has wide range wavelength in both transmittance and absorption 268 up to 418 nm, the absorption range of iodine 282 up to 332 nm, where absorption rate for Rhodamine B 262 to 340 nm. In fig (4.5) iodine has negative reflection coefficient while coumarin500 and Rhodamine B with positive reflection coefficient.

In fig (4.6) the relation between excitation coefficient and wavelength, the maximum excitation coefficient occurred for Rhodamine B while minimum excitation for Iodine.

In fig (4.4) the energy gap for the different sample is related as:

E_g (coumarin500) = 3.479 eV.

E_g (Rhodamen B) = 3.683 eV.

E_g(Iodine) = 3.781 eV.

It is concluded the iodine has maximum energy gap and less absoptivity and negative reflection coefficient and higher transmittance and low excitation energy at 308 nm. While Rhodamine B has the mid energy gap, maximum reflection coefficient low absorption coefficient and higher excitation coefficient coumarin500 has wide range of wavelength for absorption coefficient reflective case and excitation coefficient. In fig (4.7) the Rhodamine B is higher Refractive index are 2.7 in wavelength 300nm, while the coumarin500 has wide range of wavelength for Refractive index from 266 up 418 nm. In fig (4.8) the relation between real dielectric constant and wavelength for three samples, and is quite similar for the relation between imaginary dielectric constant and wavelength, the iodine is minimum dielectric constant, while the coumarin500 has wide range of wavelength for dielectric constant from 268 up 418 nm, and Rhodamine B has maximum dielectric constant. The silicon dioxide doped with Rhodamine B is highest in all optical properties studied, except transmission and Energy Gap, while the Coumarin500 has a wide range of wavelengths for all optical properties studied, ranging from 268 to 418 nm.

4.3 Recommendations

1. Conducting further research on silicon dioxide by doped it with different materials to improve its optical properties.

2. Interest in studying thin films and use them in electronic devices.

3. Establishment of advanced research centers at the Sudan University Science and Technology contains all the processes and techniques of Deposition and Coating.

References

[1] B. Bhushan, Handbook of Nanotechnology (Springer, Berlin, 2004).

[2] Mohammed S, Abdalla S, Introduction in Nanotechnology, Saudi, 2007.

[3] Vladislav G. Il'ves, Michael G. Zuev, Properties of Silicon Dioxide Amorphous Nano Powder Produced by Pulsed Electron Beam Evaporation, Journal of Nanotechnology, Russia, September 2015.

[4] Yong Yang, Masae Takahashi, Hiroshi Abe and Yoshiyuki Kawazoe, Structural, Electronic and Optical Properties of the Al2O3 Doped SiO_2: First Principles Calculations, Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan 2008.

[5] Fozia Haque, Syntheses and Spectroscopic Characterization of Coumarin440 dye Doped Silica gel Rods, Optik International Journal for Light and Electron Optics 125 (10), 2308- 2312, 2014.

[6] S. S. Nekrashevich and V. A. Gritsenko, Electronic Structure of Silicon Dioxide (A Review), in Russia 2013.

[7] Charles P.poole ,Jr , Frank j , owens "Introduction nanotechnology", Canada 2003.

[8] W.H. de Jong, B. Roszek, R.E. Geertsma, Nanotechnology in medical applications: possible, risks for human health. RIVM report 265001002, 2005 (RIVM, National Institute for Public Health and the Environment, Bilthoven, 2005).

[9] opportunities and risks of nanotechnologies report in co-operation with OECD international futures program 2006.

[10] K. Suenaga, C. Colliex, N. Demoncy, A. Loiseau, H. Pascard, F, Willaime: Synthesis of nanoparticles and nanotubes with well separated layers of boron-nitride and carbon, Science 278 (1997) 653– 655.

[11] Maheswari Majhi, Growth and characterization of SiO2 thin film on silicon substrates, National Institute of Technology, Rourkela Rourkela-769008, Orissa, India May 2013.

[12] G. Brnard, Current transport in SiO2 films grown by thermal Oxidation for metal-oxide semiconductor, International Research Journal of Engineering Science, Technology and Innovation (IRJESTI) Vol. 1(2) pp. 25-32, May 2012.

[13] C. Huang, A. Notten, N. Raster's, J. Technol. Transf. 36, 145–172 (2011)5– formation and characterization of metal Nano-particle cot in on oxide Nanosheres doctor Rerum Naturalium 24 Juni 2002.

[14] Grolik, Benno, Koppjochim, "Optical properties of thin semiconductor films", Internet Report, (2003).

[15] Jutzi, Peter and Schubert, Ulrich, Silicon chemistry: from the atom to extended systems . Wiley- VCH. ISBN 3-527-30647-1 (2003).

[16] Y. Zhou, yongyou Geny, Donghong Gu, Weibing Gu, Zhi Jiang ,"Effect of film thickness on the optical constants and optical absorption properties of NiOx thin films," physical B405 (2010).

[17] C. Zhen, Y. Liu, Y. Zhang, L. Ma, C. Pan, and D. Hou, “Room temperature ferromagnetism in Si-SiO2 composite film on glass substrate,” Journal of Alloys and Compounds, vol. 503, no. 1, pp. 6−9,(2010).

[18] G. Hart, The nomenclature of silica, American Mineralogist 12, 383{395 (1927).

[29] R. B. Sosman, The Phase of Silica (Rutgers University Press, New Brunswick, NJ, 1964).

[20] G. Hetherington, K. H. Jack, and M. W. Ramsay, The high-temperature electrolysis of vitreous silica, Part I. Oxidation, ultra-violet induced uorescence, and irradiation color," Physics and Chemistry of Glasses 6, 615 (1965).

[21] R. Bruckner, Properties and structure of vitreous silica. I," Journal of Non-Crystalline Solids 5, 123, 175 (1970).

[22] C. Tan, Determination of refractive index of silica glass for infrared wavelengths by IR spectroscopy," Journal of Non-Crystalline Solids 223, 158, 163 (1998).

[23] I. Fanderlik, Glass Science and Technology, Vol. 5: Optical Properties of Glass (Elsevier Science, New York, NY, 1983).

[24] C. F. Bohren and D. R. Hu®man, Absorption and Scattering of Light by Small Particles (John Wiley & Sons, New York, NY, 1983).

[25] E. Ellis, D. W. Johnson, A. Breeze, P. M. Magee, and P. G. Perkins, The electronic structure and optical properties of oxide glasses I. SiO2, Na2O:SiO2 and Na2O:CaO:SiO2, Philosophical Magazine B 40(2), 105, 124 (1979).

[26] Bazaka K., Jacob M.V., Bowden B.F. Optical and chemical properties of polyterpenol thin films deposited via plasma enhanced chemical vapor deposition. J. Mater. Res. 2011;26:1018−1025. doi: 10.1557/jmr.2011.23.

[27] Caldwell KL, Jones R, Hollowell JG. Urinary iodine concentration: United States National Health and Nutrition Examination Survey 2001–2002. Thyroid. 2005;15:692-9.

[28] Kiyu A, Zainab T & Yahaya A . Iodine deficiency disorders in Sarawak. Asia Pacific J Clin Nutr (7): 256-261, (1998).

[29] Sanjukta Nad, and Haridas Pal, Photo physical Properties of Coumarin-500 (C500): Unusual Behavior in Nonpolar Solvents, India J. Phys. Chem. A, 2003, 107 (4), pp 501–507.

[30] Yang, F. Preparation of uniform Rhodamine B doped SiO2/ TiO2 composite microspheres. J. Solid State Chem., 179, 457–463. (2006).

[31] David B. Hall Patrick Underhill, Spin coating of thin and ultrathin polymer films, April 2004.

[32] Allen, D. Cooksey, C., & Tsai, B. Spectrophotometry (India, 2010).