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Effect on Different Heating Time of ZnO/GO Composite in Semiconductor Materials using Hydrothermal Method

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DECLARATION

I declare that this thesis entitled Effect on different heating time of ZnO/GO composite in semiconductor materials using Hydrothermal Method is the results of my own research except as cited in the references.

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That's very kind of you.

Kesan Masa Pemanasan yang Berbeza Pada Komposit ZnO/GO dalam Bahan Semikonduktor dengan Kaedah Hidroterma

ABSTRAK

Kesan masa pemanasan berbeza pada komposit ZnO/GO dalam bahan semikonduktor dengan Kaedah Hidroterma. Dalam kajian ini, nanopartikel ZnO telah disepadukan dengan helaian GO untuk meningkatkan sifat elektronik dan struktur bahan. Kaedah sintesis hidroterma digunakan untuk memudahkan pertumbuhan terkawal ZnO pada permukaan GO di bawah pemanasan yang berbeza (6 jam, 10 jam, 14 jam, 18 jam, 22 jam) pada 180°C. Komposit telah dicirikan menggunakan pelbagai teknik, termasuk pembelauan sinar-X (XRD). Kesan masa pemanasan yang berbeza-beza terhadap ciri-ciri struktur dan morfologi komposit ZnO/GO telah dinilai secara sistematik. Tambahan pula, sifat optik dan elektronik komposit telah disiasat melalui spektroskopi UV-Visible. Variasi yang diperhatikan dalam sifat ini dikaitkan dengan masa pemanasan semasa proses sintesis hidroterma. Penemuan kajian ini menyumbang kepada pemahaman yang menyeluruh tentang hubungan sintesis-struktur-sifat dalam komposit ZnO/GO, memberikan pandangan tentang pengoptimuman prestasi mereka untuk aplikasi semikonduktor. Keadaan sintesis yang disesuaikan yang diterokai dalam penyelidikan ini menawarkan maklumat berharga untuk mereka bentuk bahan semikonduktor dengan ciri yang dipertingkatkan, memegang potensi kepentingan untuk aplikasi dalam peranti elektronik dan sistem optoelektronik.

Kata kunci: Zink oksida, Graphene oksida, Keadah Hidroterma, XRD danUV-Vis

Effect on Different Heating Time of ZnO/GO Composite in Semiconductor Materials by Hydrothermal Method

ABSTRACT

Effect on different heating time of ZnO/GO composite in semiconductor materials by Hydrothermal Methods. In this study, ZnO nanoparticles were integrated with GO sheets to enhance the material's electronic and structural properties. The hydrothermal synthesis method was employed to facilitate the controlled growth of ZnO on the GO surface under different heating (6 hours, 10 hours, 14 hours, 18 hours, 22 hours) at 180°C. The composites were characterized using various techniques, including X-ray diffraction (XRD). The impact of varied heating times on the structural and morphological features of the ZnO/GO composites was systematically assessed. Furthermore, the optical and electronic properties of the composites were investigated through UV-Visible spectroscopy. The observed variations in these properties were correlated with the heating time during the hydrothermal synthesis process. The findings of this study contribute to a comprehensive understanding of the synthesis-structure-property relationships in ZnO/GO composites, providing insights into the optimization of their performance for semiconductor applications. The made synthesis conditions explored in this research offer valuable information for designing semiconductor materials with enhanced characteristics, holding potential significance for applications in electronic devices and optoelectronic systems.

Keywords: Zinc oxide, Graphene oxide, Hydrothermal method, XRD and UV-Vis

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LIST OF ABBREVIATIONS

ZnO	Zinc Oxide
GO	Graphene Oxide
ZnCI2	Zinc Chloride
NaOH	Sodium Hydroxide
UV-vis	Ultraviolet-Visible
XRD	X-Ray Diffraction Analysis

LIST OF SYMBOLS

D	the average crystallite size
K	the shape factor
λ	the wavelength of the X-ray radiation/the wavelength of the light
β	the full width at half maximum (FWHW) of the diffraction peak
θ	the Bragg angle
µL	microliter
Eg	the band gap energy
Ev	the energy of the top the valence band
h	Planck's constant
c	the speed of light in a vacuum
v	the frequency of the light
℃	Celsius
Nm	nanometre
Å	the angstrom unit
eV	electron Volt

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Semiconductor materials are essential for creating numerous electronic components, including solar cells, sensors, and transistors. Researchers are always looking for new ways to enhance the qualities and capabilities of these materials to improve performance. The creation of composite materials, which combines several components to synergistically harness their unique properties, is one possible route.

ZnO/GO composites require a crucial heat treatment step when the material is exposed to various temperatures and durations. In shaping the structural characteristics, morphology, and electrical components, this heat treatment is crucial. In order to modify the characteristics of ZnO/GO composites to satisfy certain device requirements, it is crucial to comprehend how varied heating times affect these materials.

The size of zinc oxide nanoparticles (ZnO), which typically range from a few nanometers to many tens of nanometers, is incredibly small. The unique traits and behaviours of these nanoparticles make them extremely desirable in a variety of applications. Additionally, because of their smaller size at the nanoscale, zinc oxide nanoparticles have better electrical characteristics. This enhances performance by enabling the integration of ZnO nanoparticles into electronic devices and sensors and efficient charge carrier transfer.

The derivative of graphene, which is a two-dimensional substance made of a single layer of carbon atoms organized in a hexagonal lattice, is called graphene oxide (GO). By oxidizing graphene, functional groups containing oxygen, such as hydroxyl, epoxy, and carboxyl groups, are added to the surface of the material, yielding graphene oxide. In addition to introducing hydrophilicity, the oxygen-containing groups also change graphene's electrical characteristics, turning it into an insulating substance. By adjusting the degree of oxidation and reduction processes, this feature enables the tuning of electrical conductivity and other electronic properties of materials based on graphene oxide.

1.2 Problem Statement

1. To study about ZnO/GO composites' combustion temperature is a crucial characteristic that can considerably impact both its properties and performance. This indicates that the impact of a change in combustion temperature on the properties of the composite has not been fully examined. Customizing composites and improving production methods for uses in industries like electronics. The ZnO nanoparticles in the composite might alter in shape and crystal structure depending on the firing temperature. Higher temperatures encourage the annealing and sintering of ZnO particles, which improves crystallinity and grain development. This may have an impact on ZnO's optical and electrical characteristics, including charge carrier mobility, absorption, and emission. The GO matrix or other organic additions may be lost because of excessive temperatures degrading or combusting organic components in the composite. The composite material's stability and mechanical strength may be impacted by this.
2. To understand the relationship between ZnO/GO composites' morphology and heating temperature. To manage and modify the composite features, such as surface

area, porosity, and connection between particles, it is necessary to understand how temperature variations affect the growth and distribution of ZnO nanoparticles as well as the distribution and arrangement of graphene oxide layers.

1.3 Objectives

The objectives are:

1. To investigate the different heating time of ZnO/GO composite using hydrothermal method.

2. To characterize the morphology, crystallinity, and optical properties of ZnO–GO composites.

1.4 Scope of Study

To study different heating intervals will be used for the study to cover a range of times, enabling a thorough analysis of the composite's reaction to thermal treatment.

SEM and X-ray diffraction (XRD) are two methods that will be used to characterise the structural characteristics of the composite. These investigations will reveal details about shape, particle size, and interfacial interactions between ZnO nanoparticles and graphene oxide sheets, as well as changes in crystal structure.

The ZnO/GO composite's optical characteristics will also be investigated. The effects of heating time on changes in absorption and emission properties will be investigated using methods like UV-Vis's spectroscopy. This investigation will shed light on how altering the heating duration can modify the optical properties of the composite.

1.5 Significances of Study

The study on composite materials and their possible applications will be advanced by the investigation on the impact of various heating times on ZnO/GO composite in semiconductor materials. Researchers can gain important insights into the structural, electrical, and optical changes that happen during thermal treatment by examining the impact of heating time on the characteristics of the ZnO/GO composite. This information is essential for streamlining the manufacturing procedure and modifying the properties of the material to improve its performance in a variety of semiconductor applications. Understanding how varied heating rates affect a composite's characteristics can help you manage and modify the conductivity, bandgap, and surface morphology of the material. The investigation can also provide insight into the mechanics underlying the interaction between graphene oxide (GO) and zinc oxide (ZnO), paving the way for the creation of innovative composite materials with improved electrical and optical properties. In the end, this research advances semiconductor materials and creates new opportunities for their application in electronics, sensors, solar cells, and other cutting-edge technologies.

CHAPTER 2

LITERATURE REVIEW

2.1 Semiconductor Materials

In my research, there has recently been a lot of interest in the inclusion of graphene oxide (GO) into semiconductor composites, such as zinc oxide (ZnO). One of graphene's derivatives, graphene oxide, has exceptional qualities such a large surface area, great mechanical strength, and high electrical conductivity. The resulting ZnO/GO composite demonstrates synergistic effects that can improve material characteristics and performance when coupled with ZnO, a well-known semiconductor material. Heating the ZnO/GO composite is a frequently used technique to bring about structural changes and enhance its performance.

The impact of heat on the structural changes of The ZnO/GO composite undergoes a number of structural changes when heated. The restoration of sp2 carbon networks and the removal of oxygen functional groups take place as a result of the reduction of graphene oxide that takes place during the heating process. In addition, the heat causes ZnO nanoparticles to grow and crystallise, which aids in the development of precise structures. The degree of reduction and the size and distribution of ZnO nanoparticles within the composite are strongly influenced by the heating temperature and time.

The ZnO/GO composite's qualities can be improved by tailoring the composite's properties to the heating process. The morphology, crystal structure, and interface interactions inside the composite can be tailored by carefully adjusting the heating conditions. The optimized composite performs better in electronic and optoelectronic applications due to improved electrical conductivity, greater charge carrier mobility, and increased interfacial contact between ZnO and GO.

Heating the ZnO/GO composite has a considerable impact on its electrical and optical characteristics. When GO sheets are reduced during heating, the composite becomes more conductive, which enhances electrical performance. The addition of ZnO nanoparticles also affects the composite's bandgap energy and absorption properties, changing its optical properties including absorbance and photoluminescence. To acquire the desired optical and electrical properties for a given application, the heating parameters must be properly optimized.

2.2 ZnO/GO Composites

ZnO/GO composites are hybrid materials that combine the properties of zinc oxide (ZnO) and graphene oxide (GO). ZnO, a wide band gap semiconductor, has excellent electrical, optical, and photocatalytic properties. In contrast, GO, derived from graphene, exhibits a large surface area, high mechanical strength, and exceptional electrical conductivity. The integration of ZnO and GO in a composite structure offers the potential to synergistically enhance their individual properties and create multiple functionalities.

The synthesis of ZnO/GO composites can be achieved by various methods, including solution-based approaches, hydrothermal processes, or chemical vapor deposition. This method

enables the controlled incorporation of GO into the ZnO matrix, facilitating the formation of well-defined composite structures.

Moreover, ZnO/GO composites exhibit enhanced mechanical strength and stability compared to pure ZnO, suitable for flexible electronic and wearable devices. The combination of the semiconducting properties of ZnO and the high surface area of GO opens opportunities for the development of advanced sensors with enhanced sensitivity and selectivity.

In summary, ZnO/GO composites offer a versatile platform to develop new materials with suitable properties and improved performance. The synergistic effect arising from the integration of ZnO and GO makes this composite material very promising for various applications in semiconductor devices and beyond.

2.3 Hydrothermal Method

In materials science and chemistry, the hydrothermal method is a process frequently used to synthesis different materials, such as nanoparticles, nanowires, and thin films. This process involves adding a precursor solution containing the desired ingredients to a reaction vessel. The vessel is then sealed and heated in a pressure reactor or autoclave under carefully monitored conditions, enabling the reaction to take place in a water-based environment at high temperatures and pressures.

High pressure and temperature help the required material to develop and grow during the hydrothermal process. The environment for the reaction to occur is watery thanks to the water's role as a solvent. The length of the hydrothermal treatment as well as the temperature and pressure conditions are key factors in shaping the final material's qualities and characteristics.

Controlling the size, form, and crystallinity of the synthesized materials is one of the many benefits of the hydrothermal technique. By changing the reaction parameters, it is a flexible and reasonably easy approach that may be customized for certain uses. The hydrothermal process is also thought to be environmentally beneficial because it does not utilize any potentially toxic organic solvents.

In conclusion, the hydrothermal process is a useful tool for creating a variety of materials and is frequently used in both research and business to create sophisticated materials with desired qualities.

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

In the Table 3.1, the materials I used to make the experiment it is chemical name is liquid Graphene Oxide and the formula name for this chemical is GO. NaOH is available at lab material science in UMK which is the original owner of this chemical. The charge number for this chemical is 1034343-98-0 and the weight is 200mL. The brand name of this chemical is Sigma.

Secondly, its chemical name is Zinc Chloride nano powder and the formula name for this chemical is ZnCI2. ZnCI2 can be available at lab material science in UMK which is the original owner of this chemical. The charge number for this chemical is 1314-13-2 and the weight is 50g. The brand name of this chemical is Sigma Aldrich.

Thirdly, its chemical name is Sodium Hydroxide powder and the formula name for this chemical is NaOH. NaOH is available at lab material science in UMK which is the original owner of this chemical. The charge number for this chemical is 1310-73-2 and the weight is 1000g. The brand name of this chemical is Sigma HmbG.

Finally, I take distilled water to solve solution. The process of distillation, a method that removes impurities and minerals. In the distillation process, water is heated to its boiling point,

and the resulting steam is then cooled and condensed back into a liquid. This process effectively eliminates most contaminants, dissolved solids, and minerals present in the original water source. The resulting distilled water is known for its high purity and is commonly used in various applications where the presence of impurities is undesirable. It finds use in medical procedures, laboratory experiments, steam irons, humidifiers, automotive batteries, and in the production of cosmetics and pharmaceuticals. While suitable for specific purposes, it's important to note that distilled water lacks essential minerals and is not typically recommended for regular human consumption in large quantities due to the potential for electrolyte imbalances.

Table 3. 1: List of chemical and brand preparation ZnO/GO for Hydrothermal method.

NO.	Chemicals	Brand
1.	Graphene oxide (GO)	Sigma
2.	Zinc Chloride (ZnCI2)	Sigma Aldrich
3.	Sodium Hydroxide (NaOH)	Sigma HmbG
4.	Distilled water	Lab Material Science

3.2 Equipment

In Table 3.2, the equipment setup encompasses a variety of essential equipment tailored for diverse scientific tasks. A magnetic stirrer stands as a cornerstone, facilitating the seamless mixing, blending, and stirring of liquids, ensuring homogeneity in experimental solutions. Teflon, a versatile material revered for its unique properties, finds ubiquitous use, providing non-reactive surfaces and exceptional chemical resistance across experimental setups. Pipettes, precision instruments, dispense specific volumes of liquids with unparalleled accuracy, crucial for

meticulous measurements in analytical procedures. Complementing these are magnetic bars, which aid in stirring liquids within vessels, ensuring uniformity and consistency throughout experiments. Transitioning to more advanced techniques, X-ray diffraction (XRD) emerges as a pivotal tool for structural characterization, unravelling the atomic and molecular arrangements within crystalline samples. Meanwhile, UV-Vis's spectroscopy emerges as a cornerstone for analysing chemical structures and discerning the band gaps of semiconductors, offering insights into their optical properties with remarkable precision. Together, this array of equipment forms the backbone of scientific inquiry, enabling researchers to delve into the intricate realms of material science, chemistry, and beyond.

Table 3. 2: List of equipment to prepare the samples.

NO.	Equipment	Purpose
1.	Magnetic stirrer	To facilitate mixing, blending, and stirring of liquid
2.	Teflon	To versatile material known for its unique properties
3.	Pipette	To dispense a specific volume of liquid precisely
4.	Magnetic bar	To stir liquids
5.	X-ray diffraction (XRD)	To identify structural characterization
6.	UV-Vis Spectroscopy	To analysis the chemical structure of substrate and band gap of semiconductor

3.3 Preparation of ZnO/GO using hydrothermal method

In Figure 3.3, is for preparation of ZnO/GO using hydrothermal method the process outlined for the preparation of ZnO/GO composites involves a series of carefully controlled steps aimed at achieving the desired nanocomposite structure. Initially, a solution containing zinc chloride (ZnCl2), sodium hydroxide (NaOH), and graphene oxide (GO) is prepared, with specific quantities of each component (ZnCl2, NaOH, and GO) carefully measured out. This solution is then stirred for 30 minutes at room temperature to ensure thorough mixing. Afterward, an additional 300µL of graphene oxide is added to the solution, followed by a further 15 minutes of stirring to promote uniform dispersion.

Next, the prepared solution is transferred to a Teflon-lined autoclave, providing an enclosed environment conducive to the hydrothermal synthesis process. The samples are then subjected to varying heating times (6, 10, 14, 18, and 22 hours) in an oven, allowing for controlled nucleation and growth of ZnO nanoparticles on the surface of the graphene oxide sheets. After the designated heating period, the samples are allowed to cool to room temperature.

Following the hydrothermal treatment, the samples are filtered to separate the solid ZnO/GO nanocomposites from the solution. The filtered samples are then dried in a vacuum oven at 60°C for 2 hours, facilitating the removal of any residual solvent and ensuring the formation of a dry, homogeneous nanocomposite material.

Once dried, the ZnO/GO nanocomposites are subjected to characterization using X-ray diffraction (XRD) and UV-Vis's spectroscopy to analyze their structural and optical properties, respectively. The data obtained from these analyses are then carefully analyzed, and a

comprehensive report is prepared detailing the synthesis process, characterization results, and implications for potential applications of the ZnO/GO nanocomposites.

Figure 3. 1: Research process preparation ZnO/GO composites using hydrothermal method.

3.4 Characterization of ZnO/GO

X-ray diffraction, UV-Vis's spectroscopy, and scanning electron microscopy were used to examine the ZnO/Go nanostructure that was produced using the hydrothermal approach to assess the impact of altering the reaction temperature on the particle sizes.

3.4.1 X-Ray Diffraction (XRD)

Using a Bruker D2 Phaser for X-ray diffraction (XRD), the phase identification and crystallinity of the ZnO/GO compound were investigated. This provided detailed information about the chemical composition and crystallographic structure of the compound. The sample, typically in powdered form, is mounted on a goniometer stage within an X-ray diffractometer. Upon exposure to X-rays, the crystalline lattice of the ZnO/GO sample diffracts the radiation, producing a unique diffraction pattern. Interpretation of this pattern involves identifying the positions and intensities of diffraction peaks, which correspond to specific crystallographic planes within the sample.

By comparing the obtained diffraction pattern to a database of known patterns, the phases present in the sample can be identified. Additionally, quantitative analysis of peak intensities allows for the determination of crystallite size and crystallinity, providing insights into the structural properties of the material. Overall, XRD serves as a powerful tool for elucidating the crystal structure and phase composition of ZnO/GO, essential for understanding its properties and potential applications in various fields.

3.4.2 UV-Vis Spectroscopy

UV-Vis Pharo 300, also known as ultraviolet-visible absorption spectroscopy the final samples' band gap of the semiconductor and substrate's chemical structure were analysed using Spectro quant. UV-Vis's spectroscopy involves illuminating the sample with ultraviolet and visible light and measuring its absorbance or transmittance across a range of wavelengths. This technique provides valuable insights into the optical properties and electronic transitions within the material. To conduct the analysis, the ZnO/GO sample is typically prepared by dispersing it in a suitable solvent and placing it in a sample holder within a UV-Vis spectrophotometer.

The instrument records the intensity of light transmitted through the sample or absorbed by the sample as a function of wavelength, generating a spectrum that reveals peaks and valleys corresponding to absorption or transmission at specific wavelengths. In the UV region, absorption peaks indicate electronic transitions related to the bandgap energy of ZnO, while the presence of GO may influence the spectrum with additional peaks or changes in intensity. By analysing these absorption peaks, researchers can estimate the bandgap energy of ZnO and gain insights into its optical properties. Additionally, quantitative analysis allows for the determination of parameters such as absorption coefficient and optical bandgap. Combining UV-Vis spectroscopy with other techniques provides a comprehensive understanding of the optical and electronic properties of ZnO/GO, which is crucial for various applications such as optoelectronics, photocatalysis, and sensors.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 X-ray Diffraction (XRD)

In Figure 4.1, the XRD results of ZnO/GO at different heating time from 6 hours, 10 hours, 14 hours, 18 hours, and 22 hours show the lattice parameters and size in Fig 4.1. The (h,k,l) number of ZnO/GO are (100), (002), (101), (012), (110), (013), (112), and (023) and at 2θ are 31.773°, 34.420°, 36.256°, 47.540°, 56.600°, 62.383°, 67.95° and 89.620°. The inclusion of multiple heating times allows for a comprehensive examination of how ZnO/GO responds to thermal treatments. This temporal exploration provides insights into the structural changes that occur within the nanocomposite under different heating durations.

The ZnO/GO have hexagonal wutzite structure with space group P63MC (186). The sharp peaks specified the good crystallinity of the prepared crystals. The space group notation P63MC (186) provides additional insight into the symmetry of the ZnO/GO crystal structure. This specific space group denotes the symmetrical operations and arrangements of atoms within the unit cell. In the hexagonal wurtzite structure, P63MC signifies a polar space group, indicating that the structure lacks inversion symmetry. This characteristic is often associated with unique properties, making it particularly interesting for technological applications.

The (101) plane has a specific orientation within the hexagonal wurtzite structure of ZnO/GO, and the high intensity of the corresponding peak indicates a preferential crystallographic

orientation in this direction. The (101) plane corresponds to specific lattice parameters and interatomic distances within the crystal lattice. The heightened intensity of the (101) peak suggests that this crystallographic plane contributes significantly to the overall crystallinity of ZnO/GO. A well-defined and intense (101) peak implies that the nanocomposite possesses a high degree of structural order and minimal defects.

In previous study, wurtzite ZnO/GO lattice constant at 180 degrees Celsius would depend on the synthesis conditions, including the duration of the heating process and other parameters. Determining the lattice constant involves analyzing the X-ray diffraction (XRD) pattern and applying Bragg's law to the diffraction peaks.

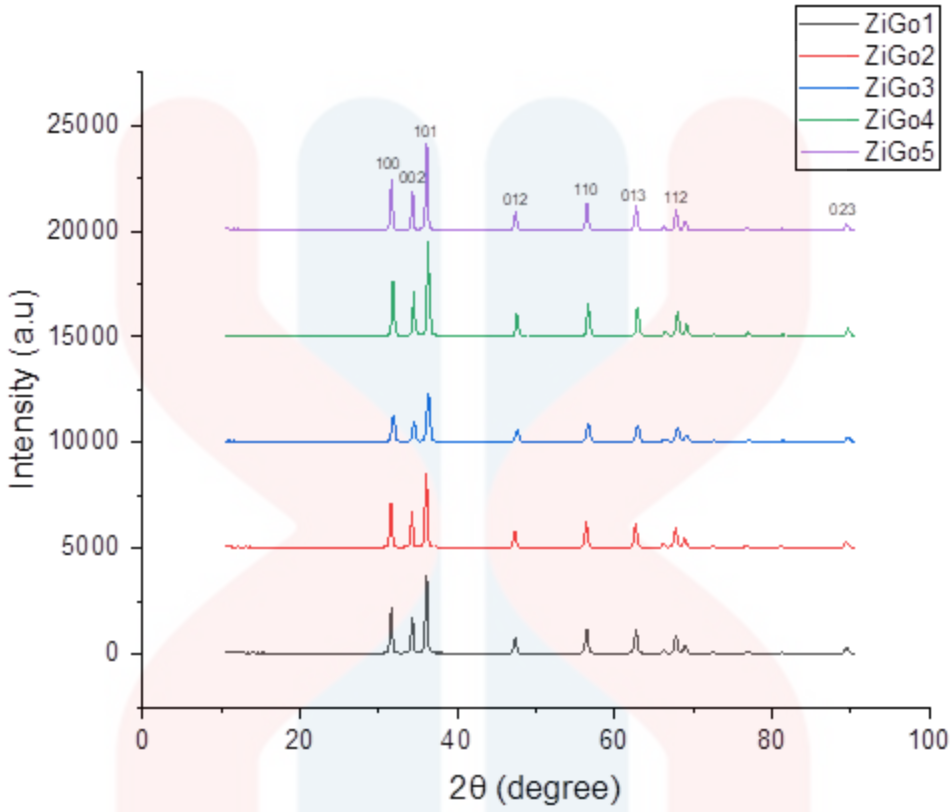


Figure 4. 1: XRD pattern structures prepared at different heating time of ZnGO/GO composite using hydrothermal method.

Table 4. 1: Unit cell parameters with different heating time of ZnG/GO composite.

ZnO/GO with different heating time (hour)	Lattice parameter (Å)			a/b ratio	c/a	Crystallite size (D), nm
	a	b	c			
6	4.8900	4.8900	3.8800	1.000	0.7935	24.5
10	4.8900	4.8900	3.8800	1.000	0.7935	24.4
14	4.8900	4.8900	3.8800	1.000	0.7935	18.1
18	4.8900	4.8900	3.8800	1.000	0.7935	23.9
22	4.8900	4.8900	3.8800	1.000	0.7935	27.9

The crystallite size of ZnO/GO with different heating time was calculated using the Scherrer equation relates the width of the diffraction peaks to the crystallite size and is expressed as shown in Equation 4.1:

$$D = \frac{K\lambda}{(d\ cos\ \theta)}$$

The provided crystallite sizes (24.5 nm, 24.4 nm, 18.1 nm, 23.9 nm, 27.9 nm) represent valuable information about the structural characteristics of the materials under investigation. This essay explores the significance of these crystallite sizes, potential implications for the materials, and factors influencing their variations.

The range of crystallite sizes (18.1 nm to 27.9 nm) suggests heterogeneity within the samples or conditions under investigation. Such variations could arise from differences in synthesis methods, processing parameters, or post-treatment steps. Larger crystallite sizes may indicate better crystallinity or slower crystal growth, while smaller sizes may suggest the presence of smaller, possibly more disordered, crystalline domains.

The Figure 4.2 the average crystallite size of ZnO/GO plotted against heating time. The average crystallite size is a way of measuring the typical size of crystalline regions within a material. As you can see from the graph, the average crystallite size increases with increasing heating time. This is because longer heating times provide more energy for the atoms in the ZnO/GO to rearrange and form larger crystals.

The data provided also includes the lattice parameters of ZnO/GO for different heating times. Lattice parameters define the fundamental unit cell of a crystal structure. In this case, the table shows that the lattice parameters of ZnO/GO remain relatively constant with heating time.

This means that the overall crystal structure of ZnO/GO is not significantly affected by the heating process, even though the individual crystallite sizes are growing.

Overall, the Figure 4.2 and the Table 4.1 together provide information about how heating time can influence the crystal structure of ZnO/GO nanocomposites. The data shows that while the average crystallite size increases with heating time, the underlying lattice parameters remain relatively stable.

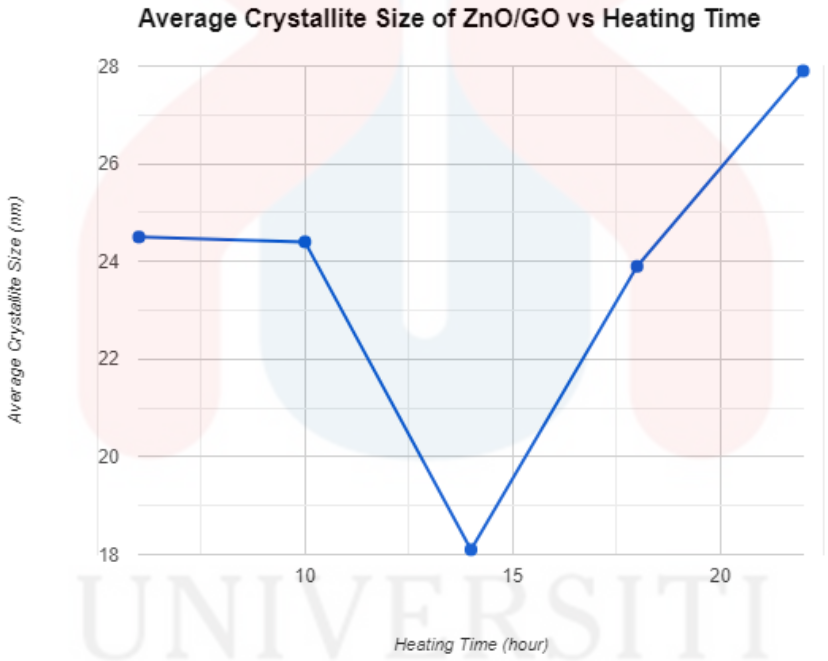


Figure 4. 2: Average Crystallite Size of ZnG/GO of different heating time by hydrothermal method.

In figure 4.3, the lattice parameters of ZnO/GO (a, b, and c) and the average crystallite size were measured for different heating times (6 hours, 10 hours, 14 hours, 18 hours, and 22 hours). The lattice parameters remained constant at around 4.8900 Å for a and b, and 3.8800 Å for c, regardless of the heating time. The a/b ratio was also constant at 1.000, indicating a hexagonal crystal structure. The c/a ratio was around 0.7935, suggesting a slight distortion in the hexagonal structure. The average crystallite size showed some variation, with the highest value (27.9 nm) observed for a heating time of 22 hours.

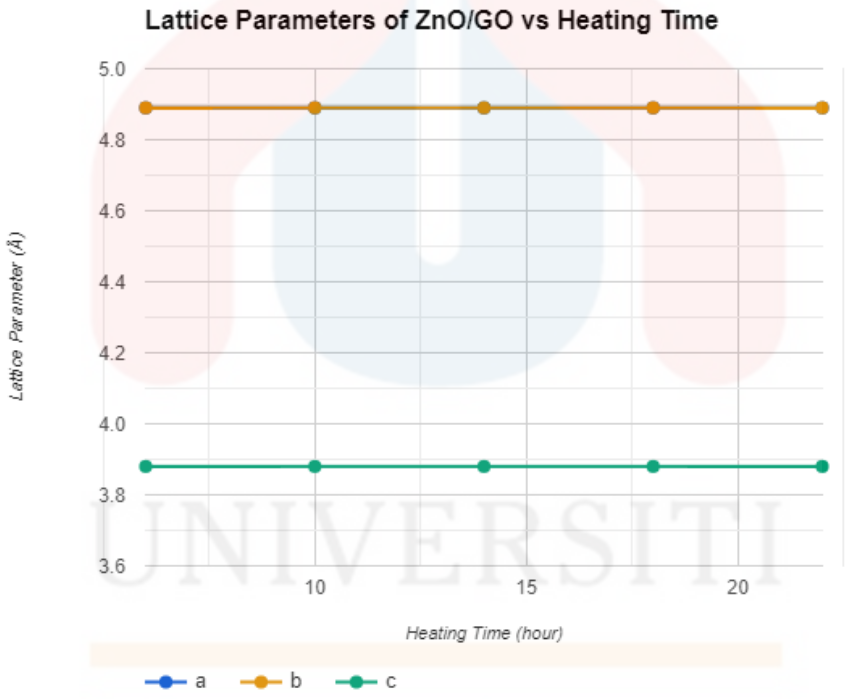


Figure 4. 3: Lattice Parameter of ZnO/GO of different heating time by hydrothermal methods.

4.2 UV-Vis Spectroscopy (UV-VIS)

The UV-Vis spectroscopy graph for all samples prepared at different hours (6 hours, 10 hours, 14 hours, 18 hours, and 22 hours) at 180°C has been shown in figure 4.4. At the wavelength at 300nm until 800nm, the absorption spectrum of ZnO/GO sample will be seen the start nanostructures in samples. From the graph we can see the peaks of absorbance at 419nm. The 419nm show the spectrum light is almost all the visible spectrum radiations are transmitted by the ZnO/GO nanoparticles. At 419nm we can see that the graph thar remains shows that strong ultraviolet-visible absorption capacity at higher wavelength. The ZnO/GO exhibits an obvious light absorption capability at higher wavelengths with different hours for heating by hydrothermal method.

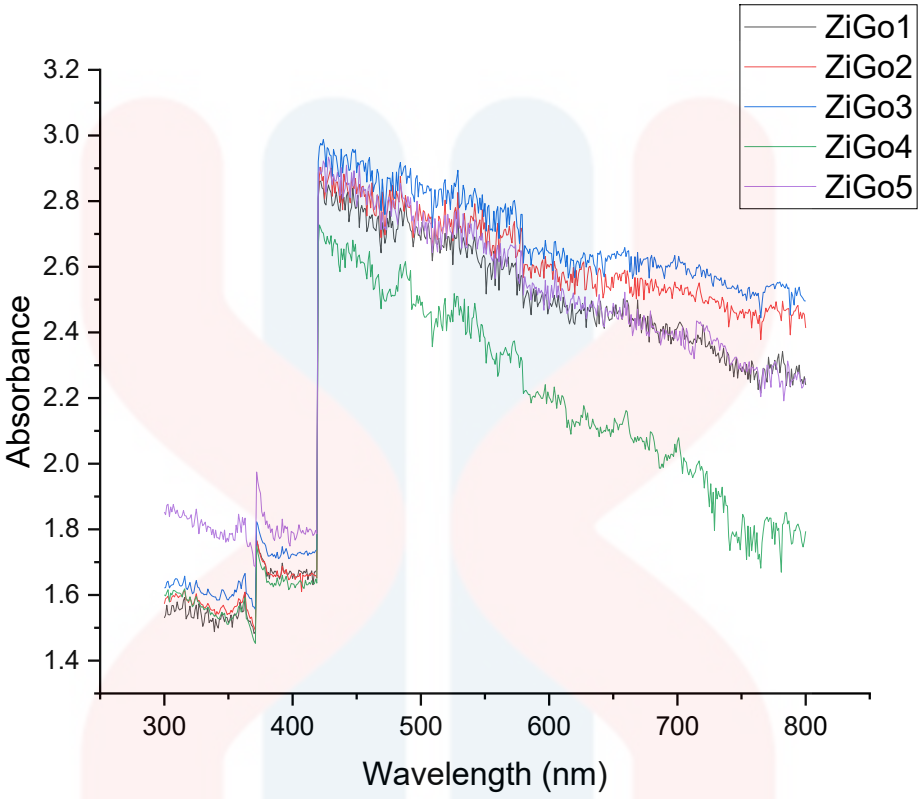


Figure 4. 4: The UV-Vis graph spectroscopy of ZnO/GO prepared at different heating time using hydrothermal methods.

4.2.1 Band Gap Determination

The energy band gap of ZnO/GO with different hours at 180°C was plotted using the Tauc graph. Can see too as the reaction hours was increase, the value of the absorption was gradually shifted to a lower wavelength, which was affected on the values of direct energy band gap transition and its particle sizes. The energy band gap was calculated from the Tauc plot relation from equation 4.2. The data was analysed from absorption versus wavelength graph which were plot using Origin Software. The energy band gap was plotted using $(ahv)2$ (eV cm-1)2 for y-axis and hv for x-axis.

$$(ahv)^{\frac{1}{n}} = A(hv - E_g)$$ Equation 4.2

This equation is derivered by Tauc and David-Mott relation refer to equation 4.3, where a is absorption, hv is proton energy, K is the energy independent constant and E_g is the optical band gap. The exponent n is the nature of transition for direct band gap is 2 where areas for indirect band gap is ½.

$$E_g = hv$$ Equation 4.3

$$v = \frac{c}{\lambda}$$ Equation 4.4

$$E_g = \frac{hc}{\lambda}$$ Equation 4.5

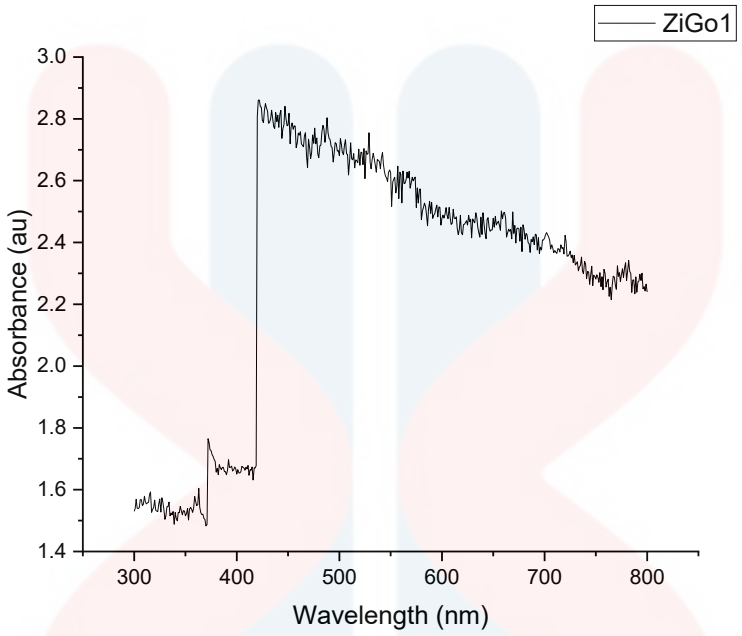
Max Planck Equation 4.5 was used for conversion of wavelength to energy. Equation 4.6 inserted into Equation 4.5 and Equation 4.6 exists. Next, (ahv) n equation is used for y-axis which (α) is for absorbance coefficient and hv is used for photonic energy. Alpha (α) can be calculated by Beer Lambert's law that showed in equation 4.7:

$$\frac{I}{I_\circ} = e^{-al}$$ Equation 4.6

This equation of 4.6, I stand for intensity transmitted light, $I_{\circ}$ for intensity of incident light, α stand for the absorption coefficient and I for path length of light in absorbance take place.

Figure 4.5 (a), 4.6 (a), 4.7 (a), 4.8 (a), and 4,9 (a) shows the UV-Vis graph absorbance versus wavelength for ZnO/Go with different temperature while in Figure 4.5 (b), 4.6 (b), 4.7 (b), 4.8 (b), and 4,9 (b) shows the value of energy band gap obtained from Tauc plot graph at different hours at 180°C of ZnO/Go nanoparticles which is (E_g) 1.86 eV, 1.81 eV, 1.72 eV, 1.97 eV and 1.77 eV from different hours of ZnO/Go which 6 hours, 10 hours, 14 hours, 18 hours and 22 hours at 180°C. Based on this results, we can see the lower of band gap is 1.72 eV and the highest of band gap is 1.86 eV.

(a)



(b)

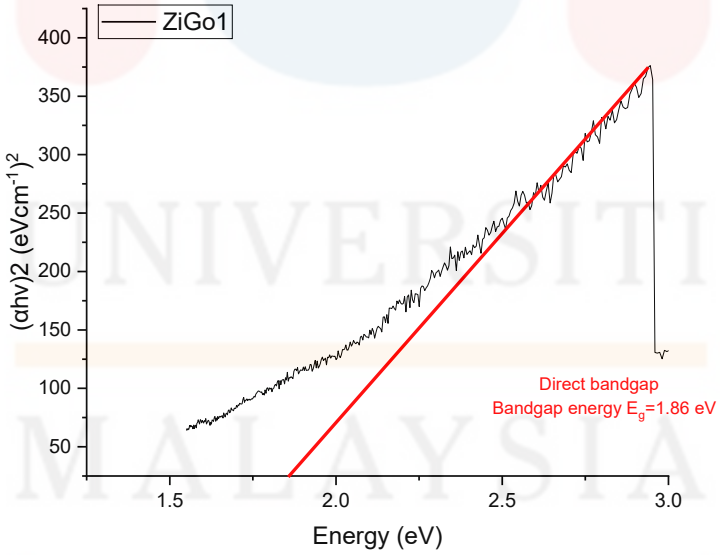
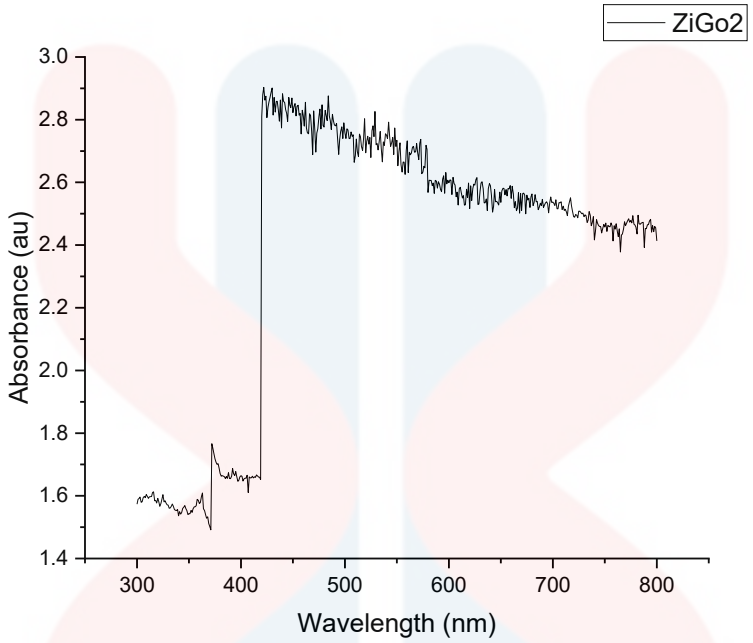


Figure 4. 5: Shows (a) The UV-Vis of different heating time (6 hours) ZnO/GO nanostructure and (b) The Tauc Plot from UV-Vis's analysis of different heating time (6 hours) Zno/GO for the band gap.

(a)



(b)

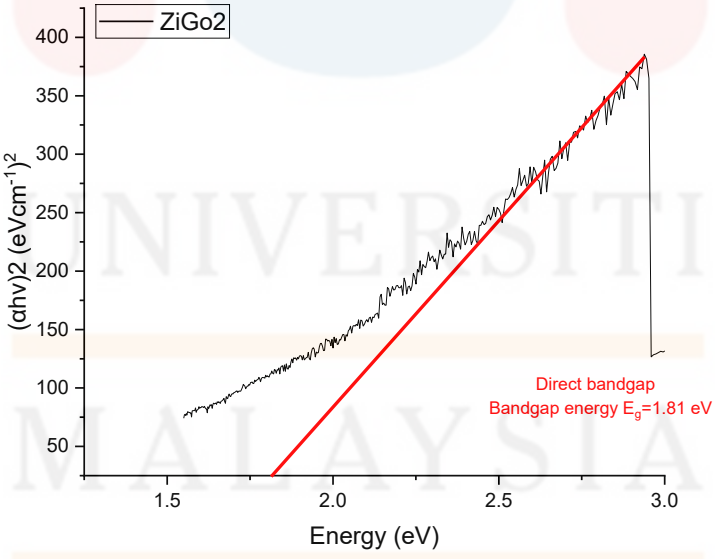
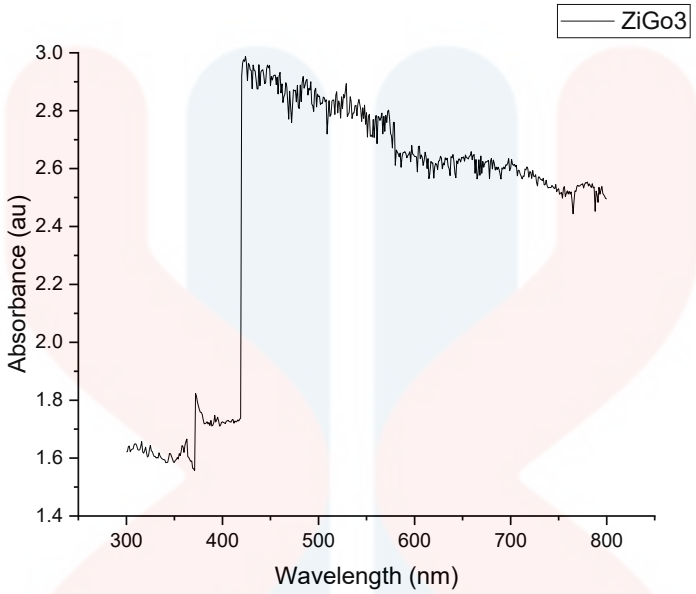


Figure 4. 6: Shows (a) The UV-Vis of different heating time (10 hours) ZnO/GO nanostructure and (b) The Tauc Plot from UV-Vis's analysis of different heating time (10 hours) Zno/GO for the band gap.

(a)



(b)

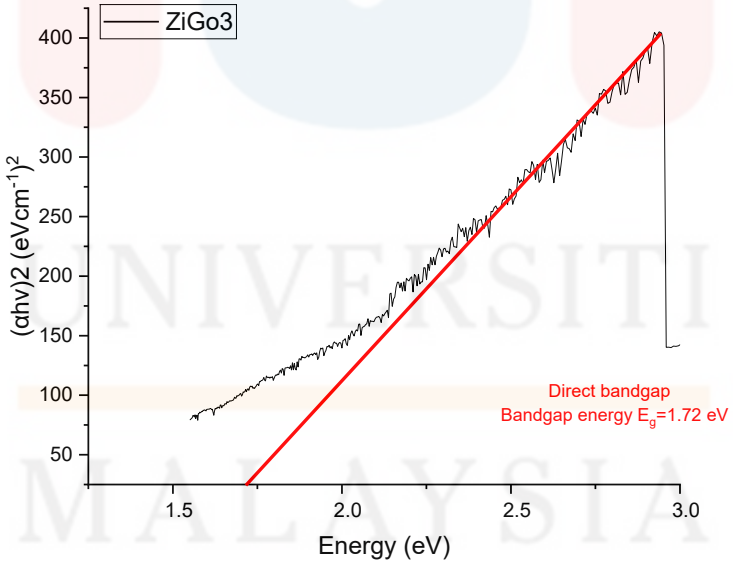
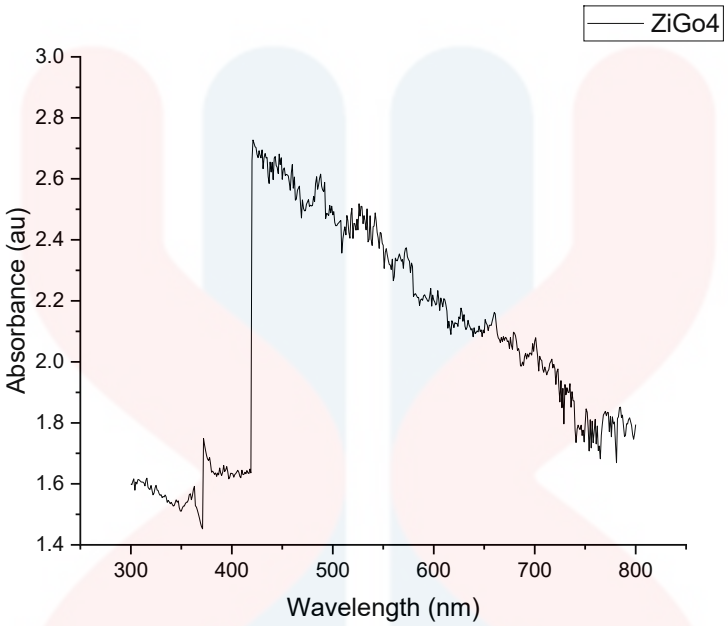


Figure 4. 7: Shows (a) The UV-Vis of different heating time (14 hours) ZnO/GO nanostructure and (b) The Tauc Plot from UV-Vis's analysis of different heating time (14 hours) Zno/GO for the band gap.

(a)



(b)

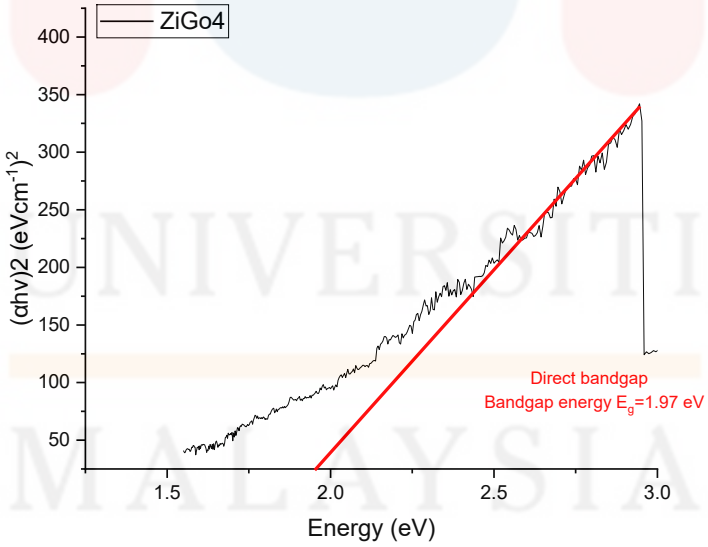
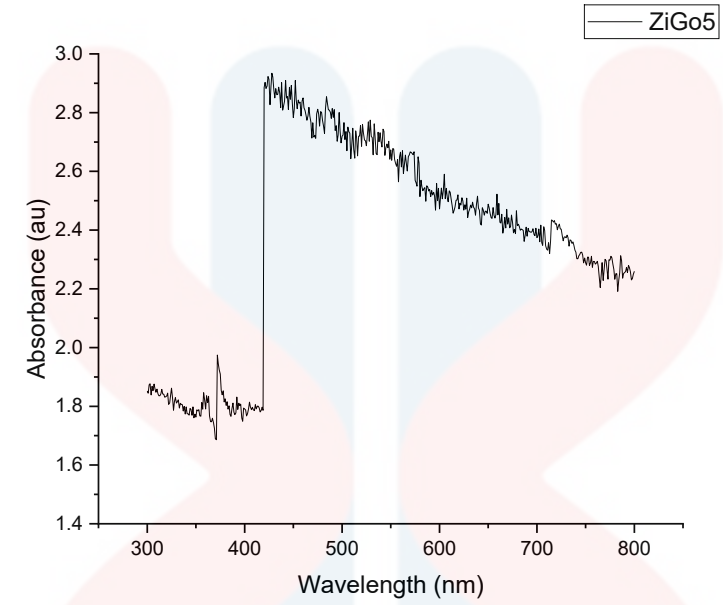


Figure 4. 8: Shows (a) The UV-Vis of different heating time (18 hours) ZnO/GO nanostructure and (b) The Tauc Plot from UV-Vis's analysis of different heating time (18 hours) Zno/GO for the band gap.

(a)



(b)

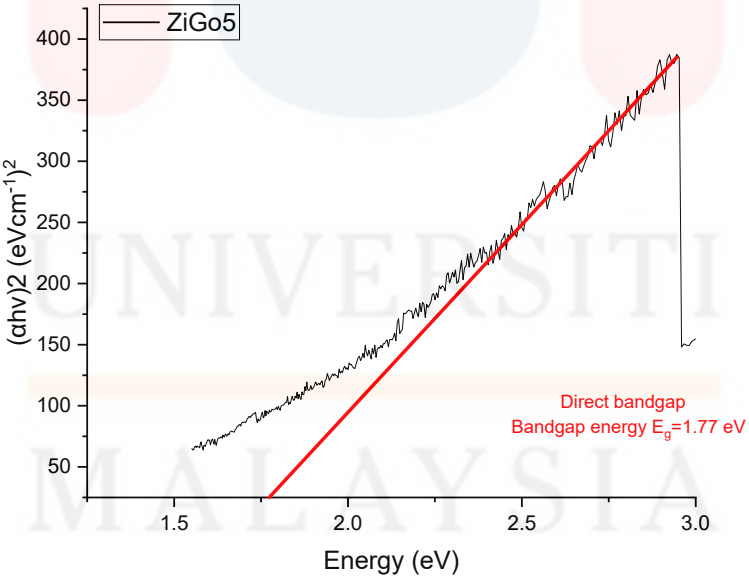


Figure 4. 9: Shows (a) The UV-Vis of different heating time (22 hours) ZnO/GO nanostructure and (b) The Tauc Plot from UV-Vis's analysis of different heating time (22 hours) Zno/GO for the band gap.

Table 4. 2: List of energy band gap for different heating time ZnG/GO by hydrothermal method.

Time of heating ZnO/GO (hours)	E_g = (eV)
6	1.86
10	1.81
14	1.72
18	1.97
22	1.77

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Our investigation into the Effect on Different Heating Time of ZnO/GO Composite in Semiconductor Materials using Hydrothermal Method. We observed that longer heating durations generally promoted an increase in the average crystallite size of ZnO within the composite. This implies that more energy provided by extended heating allows atoms to rearrange and form larger crystalline domains. Interestingly, the fundamental crystal structure of ZnO, as defined by its lattice parameters, remained relatively unaffected by heating time. While this suggests the overall structure isn't drastically altered, further research is needed to fully understand the interplay between heating, crystallite size, and the material's properties.

Furthermore, the band gap energy, a crucial parameter for semiconductors, exhibited variations with heating time. Although the exact trend requires further exploration, it highlights the potential influence of heating duration on the optoelectronic properties of ZnO/GO composites.

Illusion, our findings demonstrate that the hydrothermal method with controlled heating times offers a promising approach for tailoring the structural and potentially the optoelectronic properties of these composites. Optimizing heating parameters can help achieve desired material characteristics for specific semiconductor applications. Future studies should delve deeper into the mechanism behind band gap variations, explore different heating profiles, and evaluate the

performance of these materials in actual devices. By delving further into these aspects, we can unlock the full potential of ZnO/GO-based semiconductors for advanced technological applications.

5.2 Recommendations

For future research, the following experiments are suggested for future works:

1. Investigating synthesis parameters beyond heating time, such as temperature, pressure, and precursor concentrations, could provide insights into fabrication processes and optimize synthesis protocols for ZnO/GO composites.
2. Comprehensive characterization studies on ZnO/GO composites' structural, optical, and electronic properties are crucial, using techniques like X-ray diffraction, electron microscopy, UV-Vis's spectroscopy, and electrical measurements.
3. The study highlights the importance of evaluating the environmental impact of ZnO/GO composite synthesis and exploring sustainable synthesis routes for the development of sustainable semiconductor technologies.
4. The commercial viability of ZnO/GO composites relies on transitioning from laboratory-scale synthesis to scalable manufacturing processes, ensuring control over material properties and performance.
5. ZnO/GO composites' potential in energy storage, sensing, catalysis, and biomedical devices is promising, fostering interdisciplinary collaborations, and uncovering novel functionalities.

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