Optical properties of ZnO nanorods and ZnO/CdZnS thin films

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Zinc oxide nanorods (ZnO NRs.) film prepared by hydrothermal method and zinc oxide film chemically coated with a trinary semiconductor (CdZnS) thin layer was investigated in this work. Optical properties include transmission, absorption spectra and energy band gaps have been tested for prepared thin films. it was observed that the absorption edge of the films after coating shifted towards higher wavelengths. Also there is a remarkable reduction in energy gap for ZnO/CdZnS film with compare to ZnO NRs. Film. The energy gap of ZnO NRs was 3.2 eV and 2.5 eV for ZnO/CdZnS film.

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1. Introduction

One dimension nanostructured semiconductor rods, wires, belts, and tubes have received a lot of attention recently because of their countless unique properties and the possibility that they could be used as building blocks for future electronics and photonics [1-3]. In addition to medical and environmental applications [4,5]. Zinc oxide (ZnO) is an II-VI compound semiconductor made up of Zinc ions (Zn2+) and an Oxygen ion (O2-). Insoluble in water, ZnO is a white powder. Many industrial goods rely on it. among these are food (a good source of zinc), paints and ointments, batteries [6,7]. It found with a 3.44 eV direct gap at low temperatures and 3.37 eV at normal temperatures. It affects several optoelectronic applications like laser diodes, LEDs, and photodetectors. ZnO also has a 60 meV binding exciton energy [8,9].

There are many methods for preparing zinc oxide nanostructures, including biological, physical and chemical. One of the most important of these methods is the hydrothermal method, which has received wide interest by many researchers because of its advantages compared to other methods [10-12].

The optical properties of semiconductors are considered one of the most important properties of these materials because many electronic and optoelectronic applications depend on controlling these properties such as the absorption spectrum and the energy gap [13-15] . The process of surface modification and coating with other materials as surface layers is one of the most important methods and attempts to control the optical properties of semiconductor [16-18]. There are many studies on the surface coating of ZnO or thin films by semiconductors to control their physical properties. These materials are CdS and ZnS [19]. These coating processes can be done in many ways, one of the most important of these methods is the chemical bath deposition method [20], which has received wide interest by many researchers because of its advantages compared to other methods, as it is considered an easy, fast, and inexpensive method as well as does not require large equipment [21-23].

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The CdxZn1-xS is a II-VI semiconductor with variable band gap as function of composition between 2.42 eV for CdS and 3.70 eV for ZnS [24,25]. Cadmium Zinc Sulfide (CdZnS) NPs which are synthesized using appropriate Cd:Zn ratio, have been widely used as capable wide band gap materials for fabricating hetero-junction solar cell devices [26,27].

In the present work, an attempt is made to manipulate the optical properties (the absorption spectrum, emission spectrum, and band gap) of ZnO NRs thin film by coating it with a thin layer of CdZnS by chemical bath deposition method.

2. Experimental work

Seed layer was prepared using sol-gel formation by dissolving 0.5 M of zinc acetate in ethanol solution with stirring at 60 °C for 2-3 h until a clear and transparent homogeneous solution was formed. The special mechanism of the solgel process, firstly Zn (Ac) is hydrolyzed in the absolute ethanol. The spin coating is a fast and easy technique to deposite thin and homogeneous films out of solutions. It has been used to prepare the seed layer of ZnO nanorods on the cleaned glass substrates.

After formation of the seed layer, the growth of pure ZnO nanorods were formed through the hydrothermal method, which typically carried out at elevated temperatures and pressures in a Teflon-sealed stainless steel autoclave; where ZnO NRs were prepared through the hydrolysis at 120 Co ± 10 oC. Both Si and glass substrates with a seed layer were putted vertically inside Teflon vessels filled by of aqueous solution contains 0.05 M zinc nitrate hexahydrate Zn (NO3)2.6H2O and 0.05 M Hexamethylenetetramine HMTA; C6H12N4 sealed and heated at 120 oC ± 10 °C for 3 h. Then, the substrate removed from the Teflon vessel, cleaned by distilled water and all the samples were annealed for 1 h in furans at 375 °C ± 10 °C as shown in Figure 2-3. The concentration of the solution controls the density of nanorods arrays, while temperature and time greatly affect the morphology of the grown ZnO NRs formed such as the height and width of rods.

To coated the surface of CdZnS layer the Pure ZnO film was inserted in a backer containing 0.1M/5 20ml of cadmium cloride CdCl2 and 0.1M/20 ml of Zinc nitride [Zn(NO)3] Ammonia solution is added to adjust the pH of solution to 10 and the total volume was 100ml. 20 ml of 0.1 M of thiourea was added slowly to the above mixture. After stirred the solution for 5 min, the substrates are immersed vertically in the beaker and then placed on the hot plate under temperature of 70 oC for 60 min.

Finally, the samples are taken out of the solution and washed by distilled water to remove any contaminants and left to dry naturally. Yellowish layer covers the substrate indicates preparation CdZnS thin film.

3. Results and discussions

The surface morphology images of the grown ZnO nanorods deposited on the glass substrate and CdZnS thin film were investigated by the Field Emission Scanning Electron Microscope (FESEM) as shown in Figure 1 a and b. It can be observed from the figure 1 a that hexagonal rods shape with homogenous distribution on the surface of the substrate. The average diameters were calculated by to be 40 to 80 nm. The images clearly show the entanglement of nanorods and the formation of nano-contacts among these nanorods. Figure 1b shows the FESEM micrograph of as prepared CdZnS nanocrystalline thin film. The CdZnS is formed as nanowalls structure as shown in the image.

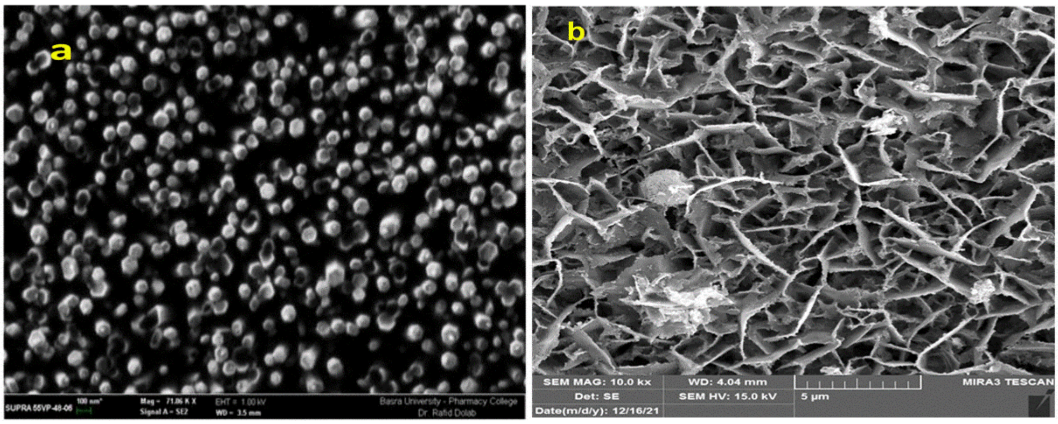

Fig. 1. FESEM of (a) ZnO NRs. (b) CdZnS thin films.

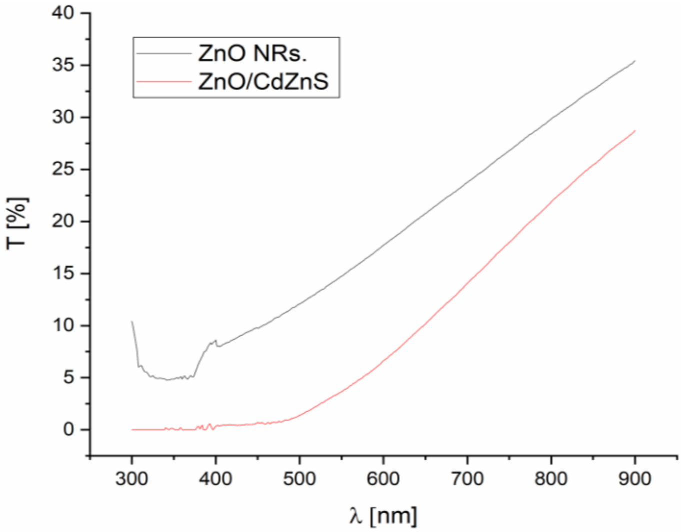

Fig. 2. transmission spectra of ZnO Nanorods and ZnO/CdZnS thin films.

The optical transmission spectra of ZnO NRs thin film and ZnO/CdZnS thin film are shown in Fig. 2. It has been observed that the transmittance varies between 25 to 35% in the visible. The transmittance decrease after coating with CdZnS layer.

Optical absorption spectra of ZnO Nanorods and ZnO/CdZnS thin films are shown in Figure 3. The absorption band edge was observed at 380 nm, 430 nm for ZnO Nanorods and ZnO/CdZnS thin films.

The optical bandgap (Eg) of ZnO NRs and ZnO/CdZnS thin films were calculated using the Tauc relation. The direct bandgaps energies were found to be 3.2 eV, 2.5 eV) for ZnO and ZnO/CdZnS thin films respectively as shown in figure 4.

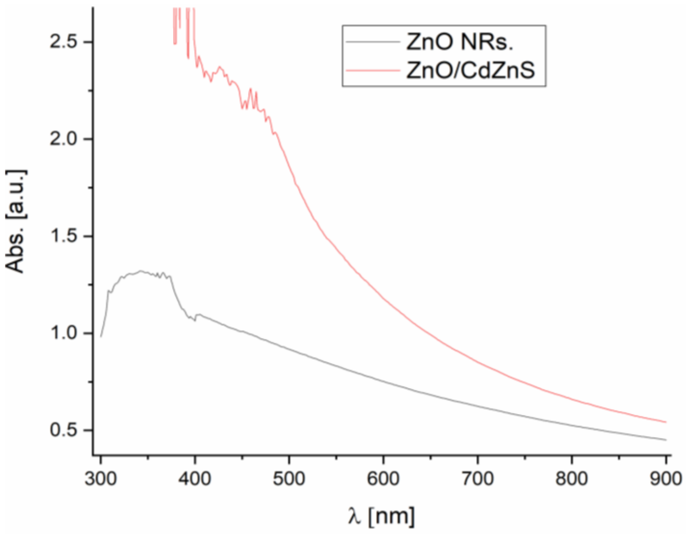

Fig. 3. absorption spectra of ZnO Nanorods and ZnO/CdZnS thin films.

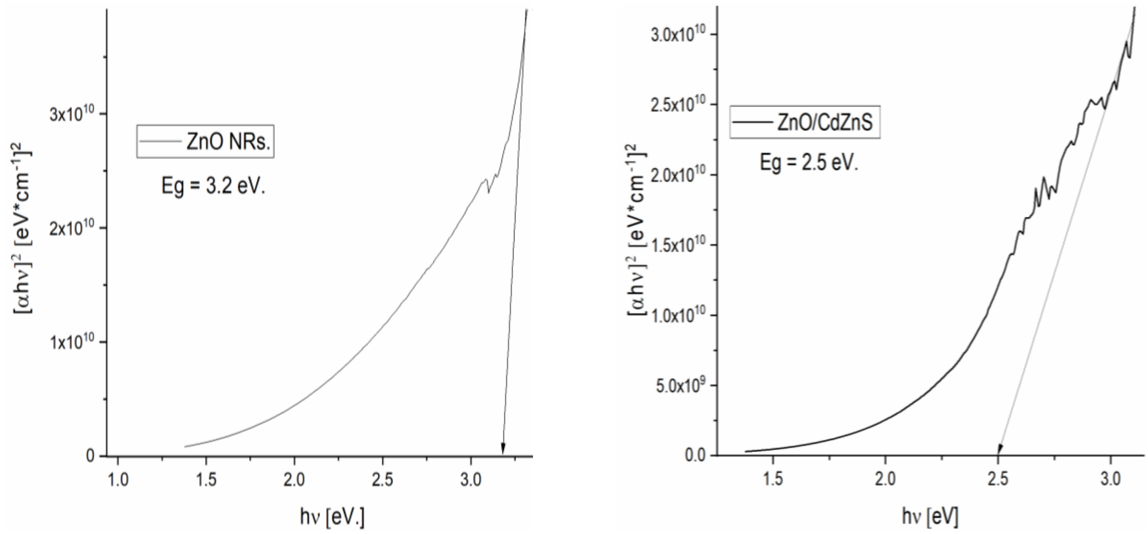

Fig. 4. direct band gaps of ZnO NRs. And ZnO/CdZnS thin films.

4. Conclusions

It was found that hydrothermal zinc oxide nanorods (ZnO NRs.) film and CdZnS thin layer-coated zinc oxide film were both studied in this work. Thin films that have been created have been tested for their optical properties, which include transmission, absorption spectra, and energy band gaps. It was discovered that following coating, the absorption edge of the films changed towards longer wavelengths. When comparing ZnO NRs to ZnO/CdZnS films, there is a significant reduction in the energy gap of coated ZnO film.

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