



## RESEARCH ARTICLE

Preparation and Characterization of Ag<sub>2</sub>ZnO nanorods SubstrateM. El-Kemary<sup>1\*</sup>, T. Fayed<sup>2</sup>, M. Gaber<sup>2</sup>, G.Kamel<sup>1</sup>

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**Abstract**

In this work, we synthesized ZnO nanorod arrays with silver nanoparticles depositing uniformly onto top, side, and bottom of nanorods, which offered much more active sites to take part in any photocatalysis work, and discuss the properties of Ag<sub>2</sub>ZnO nanorods.

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**INTRODUCTION**

ZnO is an important electronic and photonic material because of its wide band gap of 3.37 eV and high mechanical and thermal stability at room temperature [1]. The strong exciton binding energy of ZnO is much larger than that of GaN and the thermal energy of ZnO which can ensure an efficient exciton emission at room temperature. The physical characteristics of these semiconductors, such as their band gap and their electrical conductivity, affect considerably the efficiency of the solar cells [2]. ZnO in particular is frequently used in the production of dye sensitized solar cells since it has high room temperature carrier mobility ( $115-155 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ ). High carrier mobility can enhance the performance of solar cells by reducing the electron recombination, thus resulting to an increase in the photocurrent [3]. However ZnO, has a large band gap (3.77 eV), thus absorbing only the ultraviolet part of the solar spectrum, yielding low conversion efficiencies [4]. Synthesis of nanoshells can be useful for creating novel materials with different morphologies, as it is not possible to synthesize all the materials in desired morphologies. Core particles of different morphologies such as rods, wires, tubes, rings, cubes, etc. can be coated with thin shell to get desired morphology in core shell structures [5]. These materials can be of economic interest also, as precious materials can be deposited on inexpensive cores. These particles are synthesized for a variety of purposes like providing chemical stability to colloids [6], engineering band structures [7], biosensors [8], etc. Nanoshell materials can be synthesized practically using any material, like semiconductors, metals and insulators. Usually dielectric materials such as silica and polystyrene are commonly used as core because they are highly stable, chemically inert and water-soluble, therefore they can be useful in biological applications. Nanoshell particles can be synthesized in a variety of combinations such as (core-shell) dielectric-metal and [9], dielectric-semiconductor, dielectric-dielectric, semiconductor-metal, semiconductor-semiconductor, semiconductor dielectric, etc. Core shell particles can be assembled and further utilized for creation of another class of novel materials like colloidal crystal or quantum bubbles.

## 2 Experimental details

### 2.1 Materials

Zinc nitrate ( $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ), potassium hydroxide (KOH), Fluorine doped tin oxide (FTO) substrate, Silver Nitrate ( $\text{AgNO}_3$ ) and Diethanol amine were obtained from Sigma Aldrich and were used as received.

### 2.2. Synthesis of ZnO nanorods

FTO substrates were cleaned with isopropanol then with ethanol, and finally with deionized water and dried under nitrogen flow. A solution of zinc nitrate hexahydrate and potassium hydroxide in deionized water was deposited on a substrate by spin coating process for 10 s at speed of 1000rpm. The sample was annealed in air at  $350^\circ\text{C}$  for one hour. Then the substrate is immersed in a similar solution. Then put all the system in water bath at  $80^\circ\text{C}$  for 4hrs. After that, wash the substrate with deionized water to remove excess of ZnO.

### 2.3 Preparing of Ag\_ZnO

After preparing ZnO film and doing all the above steps, Ag nanoparticles have been synthesized to coat the surface of ZnO nanorods. Prepare a solution of 0.3 gm of  $\text{AgNO}_3$  in 80 ml distilled water and stirring it till completely dissolution of the particles of  $\text{AgNO}_3$ . Put few drops of diethanol amine till getting a clear solution. Put the solution in a water bath at  $90^\circ\text{C}$  then immersing the substrate of ZnO nanorods facing down in the solution for 30 mins. Take it off and wash it with water and ethanol to remove excess silver particles and leave to dry at room temperature.

### 2.4. Characterization of Ag\_ZnO nanorods

UV-visible absorption spectra were measured on a Shimadzu UV-2450 spectrophotometer. The X-ray diffraction (XRD) data were recorded on a Shimadzu XRD 6000 diffractometer with  $\text{CuK}\alpha$  radiation ( $\lambda = 1.54056 \text{ \AA}$ ). The morphological feature of the ZnO nanoparticles was observed by scanning electron microscope (FESEM, JEOL, JSM-6360 LA).

## 3. Results

Figure 1b shows the absorption spectra of ZnO nanorods substrate. It is apparent that the spectra exhibit a broad band at 382 nm the corresponding to ZnO and the other band at 425 refers to Ag nanoparticles the band gap was 2.9 eV which calculated from the following equation [10].

$$E_g (\text{eV}) = 1240 / (\text{wavelength in nm})$$

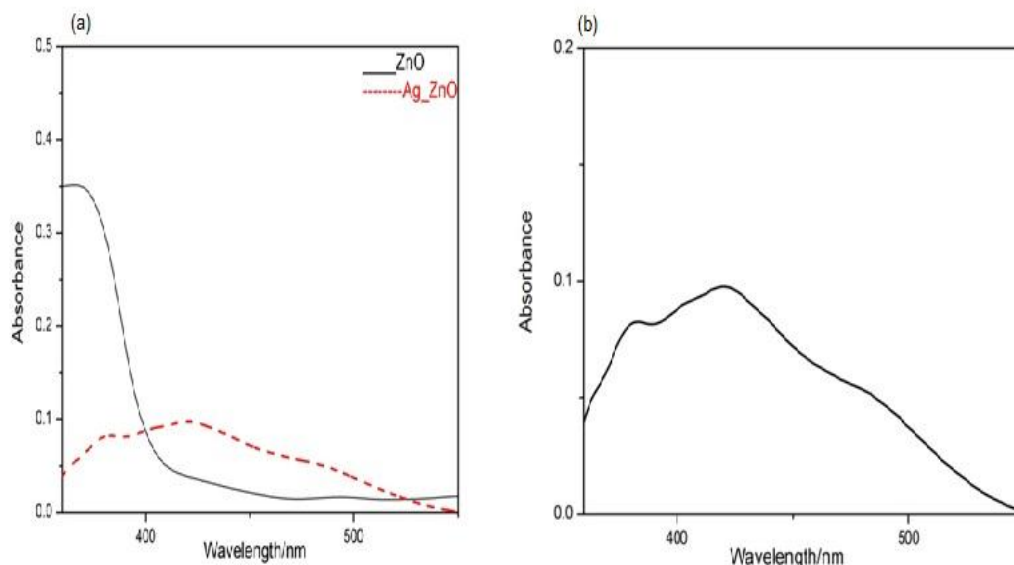


Figure 1.a) UV-vis absorption spectra for Ag\_ZnO nanorods substrate b) . UV-vis absorption spectra for ZnO and Ag\_ZnO nanorods substrate.

Figure 1 a shows that the absorption and of ZnO was located at 370nm while, Ag\_ZnO has peak at 382nm. The Surface Plasmon band of hybrid nanostructures is distinctly broadened and red-shifted by about 10 nm compared to

ZnO nanocrystals [11] and [12]. The reason for the broadening and redshift absorption is due to the strong interfacial coupling between Ag and ZnO [13] and [14]. In detail, electron transfers from Ag to ZnO in the hybrid nanostructures because the Fermi energy level of Ag is higher than that of ZnO, resulting in the deficient electrons on the surface of the Ag nanocrystals. Therefore, the deficient electrons on the surface of the Ag nanocrystals subsequently lead to the broadening and redshift of the Surface Plasmon absorption, which is consistent with that reported previously [15] and [16].

Figure 1b shows the UV of the Ag\_ZnO which is at 420nm

Figure 2 shows SEM pictures for the synthesized FTO/ZnO/Ag substrate. As can be seen, the nano particles of Ag formed on the surface of ZnO nanorods with a size of 20 nm.

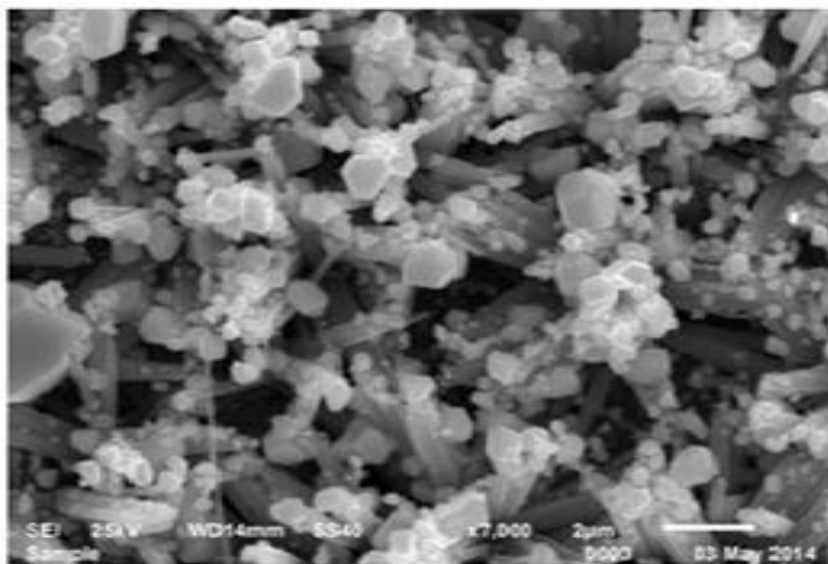


Figure 2 SEM of Ag\_ZnO nanorods.

Figure 3 shows XRD pattern of the synthesized Ag\_ZnO nanorods. All the diffraction peaks can be well indexed to hexagonal wurtzite structured ZnO with three pronounced peaks (100), (002) and (101) appearing at  $2\theta = 31.84$ ,  $34.53$  and  $36.35$  and two additional peaks at  $2\theta = 38.18$  and  $44.42$  assigned to the diffraction lines of (111) and (200) planes of the face-center-cubic (fcc) silver, respectively, which match well with those of the standard Ag\_ZnO XRD pattern (JCPDS 89-7102). No characteristic peak is observed for other impurities such as metallic Zn and  $\text{Zn(OH)}_2$  or any other impurities, indicating the purity of the products.

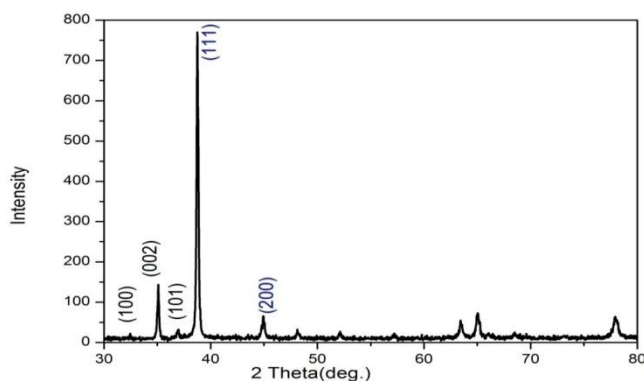


Figure 3. XRD diffraction for Ag\_ZnO nanorods substrate.

## Conclusion

Ag<sub>2</sub>ZnO has been studied and figure out its properties and characterizations by using UV spectrophotometer, X ray diffraction and Scanning electron mecescop.

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