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Effect of Thermal Annealing on the Optical Properties of AgO Thin Films

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Abstract: The aim of this work to study the effect of the thermal annealing at(100, 150 and 200°C) on the optical properties of Ag O thin films. The samples were prepared on glass slides by chemical spray pyrolysis at 50°C.The optical characteristics such as absorption coefficient, optical energy gap, extinction coefficient and refractive index were investigated by UV/V spectrophotometer in the wavelength range (380 – 500)nm. From reults show that the optical energy (Eg) values was decreased from (2.574) eV to (2.558) eV when the thermal annealed degree decreased from (200°C) to (100°C). Whereas the maximum value of the refractive index (n) for all thin films were given about (2.164). Also the extinction coefficient (K) and the real and imaginary dielectric constants. The results indicate the films have good characteristics for optoelectronic applications.

Keywords: Spray Pyrolysis, Optical Properties, Thin Films, AgO

1. Introduction

Metal oxide nanomaterials have drawn a particular attention because of their excellent structural flexibility combined with other attractive properties. These metal oxides nanostructures not only inherit the fascinating properties from their bulk form such as piezoelectricity, chemical sensing, and photo detection, but also possess unique properties associated with their highly anisotropic geometry and size confinement [1-2]. The combinations of the new and the conventional properties with the unique effects of nanostructures make the investigation of novel metal oxide nanostructures a very important issue in research and development both from fundamental and industrial standpoints [3]. Most of the I-III-VI2 compounds are direct gap semiconductors and they crystallize with the chalcopyrite structure [4].They have attracted a lot of attention due to their potential applications in opto-electronic and photovoltaic devices. Although the information on Ag chalcopyrite compounds are scarce compared with Cu compounds, there is many studies about Ag compounds are found [5-6].

Among the various thin film deposition techniques, spray pyrolysis is one of the principle methods used to produce a large area and uniform coating at simple and low cost [7-8].It is well known that the optical properties of thin films are highly sensitive to the preparation conditions and treatment conditions [9-10].

The interaction of laser beams with solid surfaces produce a variety of surface morphology changes, many of which show ripple structure with periods comparable to optical wavelength [11]. Energy-beam shaping can be used to prevent heterogeneous nucleation and promote growth of long individual grains. Argon laser offers the potential for good control over the recrystallization process because of the ability to produce a narrow molten zone and to shape the beam with a variety of optical techniques [11]. In this paper, deposition of AgO thin films by chemical spray pyrolysis and the effect of thermal annealing and laser radiation optical properties of thin films are studied.

2. Experimental Details

0.5g of silver nitrate ($AgNO_3$) solid was dissolved in 10mL of distilled water in a 100mL beaker. Then, triethanolamine TEA solution was added drop wise with constant stirring until the initially formed precipitate was dissolved (brownish solution becomes colorless). More distilled water was added to make a total volume of 80 mL. The pH of the bath was 8.0. Glass slides that have been preleased by degreasing in concentrated H_2SO_4, washed with water and detergent, and rinsed with distilled water were vertically placed into the beaker and the bath was brought to and kept at 50°C on a hot plate. After various periods of time 90 min, the coated four slides were removed from the bath, thoroughly rinsed with distilled water, and air-dried using electrical hand drier. The films were annealed at (100, 150 and 200°C) for better adhesion and homogeneity on the substrates.

Characterizations the optical properties of the films were examined by using a UV-Visible spectrophotometer at normal incident of light in the wavelength range of (380 – 500) nm. The band gaps and the refractive index of the samples were calculated from the absorption spectra.

3. Results and Discussion

The absorption coefficient (α) of the prepared Ag O thin films also of the thermal annealing at (100, 150 and 200°C) were found from the following relation [9].

$$\alpha = 2.303\, A/t \qquad (1)$$

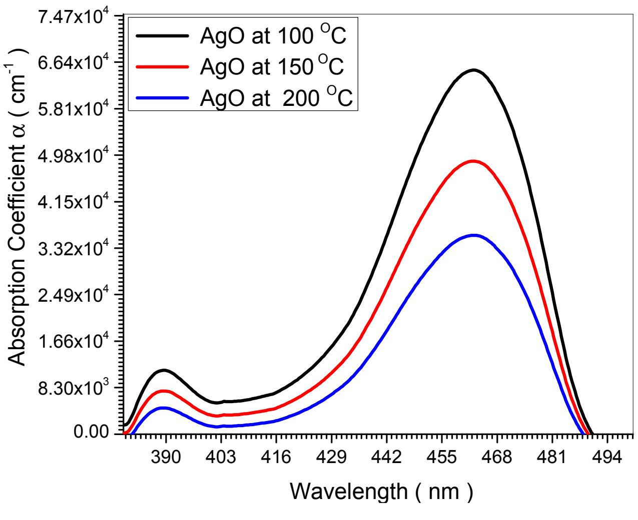

Figure 1. *The variation of absorption coefficient (α) with (λ) for Ag O thin films samples.*

Where (A) is the absorbance and (t) is the film thickness. Figure 1 Shows the plot of (α) with wavelength (λ), which obtained that the value of α > 6.64X10^4 cm-1 for all films in the visible region, this means that the transition must corresponding to a direct electronic transition [10], and the properties of this state are important, since they are responsible for electrical conduction. Also, figure 1 shows that the value of (α) for the annealed 100°C films are greater than that annealed films 200°C. The decrease in absorbance after annealing degree increase, may be due to the increase in grain size and decrease in the number of defects.

The optical energy gap (Eg) has been calculated by the relation [13]

$$(\alpha h\upsilon)^2 = C(h\upsilon - Eg) \qquad (2)$$

Where (C) is constant. By plotting $(\alpha h\upsilon)^2$ vs photon energy (hυ) as shown in figure 2. And by extrapolating the straight thin portion of the curve to intercept the energy axis, the value of the energy gap has been calculated [10]. The value of (Eg) obtained was (2.558) eV, which is approach the value of (2.574) eV reported elsewhere [6]. The value of (Eg) was decreased from (2.574) eV to (2.558) eV at thermal annealing degree decrease. The decreasing of (Eg) may be related to decrease in grain boundaries and their density due to the heating effect of the polycrystalline thin films. It was observed that the different structures of the films confirmed the reason for the band gap shifts.

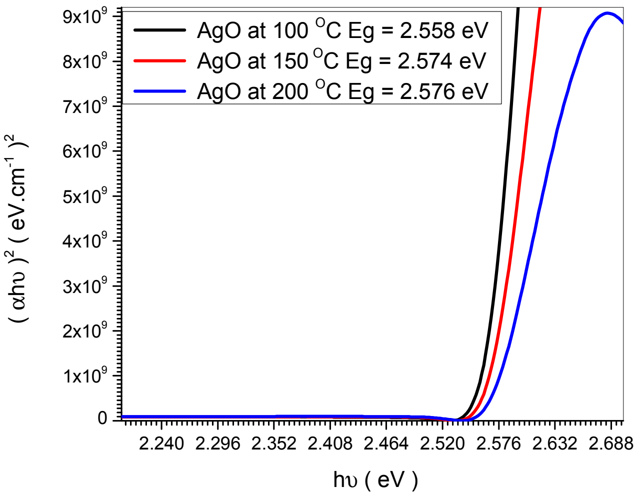

Figure 2. *The optical energy gap (Eg) value of thin films.*

Extinction coefficient (K) was calculated using the related [12].

$$K = \lambda\, \alpha / 4\pi \qquad (3)$$

The variation at the (K) values as a function of (λ) is shown in figure 3. It is observed that the spectrum shape of (K) as the same shape of (α). Figure 3 obtained the value of (K) at the visible region was depend on the film treatment method, where the value of (K) at (462) nm for annealed (100°C) is (0.241) while for annealed (150°C) at the same wavelength equal (0.180) and for annealed (200°C) equal to (0.132) at the same wavelength,this difference in (K) value become smaller at (489 nm) region.

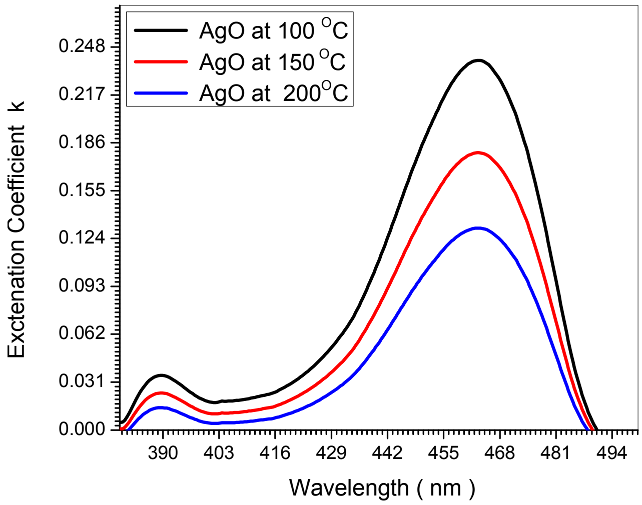

Figure 3. *The variation of extinction coefficient (K) with wavelength (λ) for thin films.*

The refractive index (n) is the relative between speeds of light in vacuum to its speed in material which does not absorb this light. The value of n was calculated from the equation [13]:

$$n = [[\frac{(1+R)}{(1-R)}]^2 - (1+k^2)\,]^2 + \frac{(1+R)}{(1-R)} \qquad (4)$$

Where (R) is the reflectivity. The variation of (n) vs (λ) is shown in figure 4. which shows that the maximum value of (n) is (2.164) for all samples at the same wavelength which is agreement with ref. [6]. From this figure also can show that the value of (n) begin to increase in the region of spectrum while (K) in its region became constant.Also (n) value decrease with annealing degree increase, this means that the film become more transparent in the (403 nm and 462 nm) region.

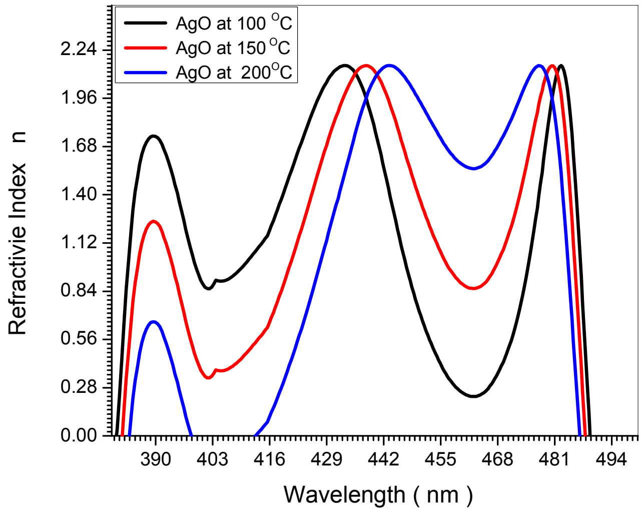

Figure 4. *The variation of refractive index (n) with wavelength (λ) for thin films.*

4. Conclusions

Ag O thin films deposited by thermal spray pyrolysis show band gap (2.558) eV which thermal (100°C) to be (2.574) at (200°C). Under these treatments the film shows a red shift of (0.016) eV for annealing degree increased in its optical spectra.Such dependence has been attributed to the structure of the film. The extinction coefficient value was increased in the visible region with treatment. The films give refractive index value equal to (2.164) in the visible region.Hence, these treatment for thin film give a best optical properties to be used for optoelectronic applications.

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