Preparation of colloidal silver oxide nanoparticles by pulsed laser ablation in methanol

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Abstract. Silver oxide AgO has been induced by Pulse Laser Ablation PLA in methanol at 600 pulses and 600 mJ as laser energy. The structural, morphological, optical and properties of the silver oxide AgO thin film have been studied. The surface morphology, crystallite size, microstrain and dislocation density were studied using X-ray diffraction (XRD). The results show that the narrow and sharp peaks at (112) and (222) plans were dominated for the crystal quality of the AgO film. Transmittance and absorption data have been used to calculate the spectral variation of their optical constants. The optical results show that the films have a band gap of 3.5 eV and AgO films transmit in the UV and visible regions.

Keywords: Silver oxide, AFM, thin film, Structure and Optical properties

1. Introduction

Silver (Ag) existence multivalent forms varied phases such as (Ag:O, Ag3:O4, Ag4:O3 and Ag2:O3) through interplay with oxygen(O2) [1]. This oxide has contrastive crystal structure lead to a diversity of properties. The most stabilized and observe phases are (Ag:O, Ag2:O) [2]. The novel interest in AgO because of its potential in optical applications. (Ag:O) semiconductor films are famous to show p-type semiconductor properties for bandgap reach to (1.20-3.40) eV. This wide range of band gap is as a result of different stoichiometric, crystal phase and properties arising from different deposition techniques [3].

(Ag:O) crystallize out by myriad patterns of crystal structures, lead to disparate of gratifying physiochemical properties like as catalytic, electrochemical, electronic and optical properties [4]. It is famed that the silver oxide phase was comparatively uniform with highness oxygen pressures and at low temperatures. The silver oxide dwell in disparate crystal shapes like as cubic, monoclinic and tetragonal [5-6]. It is witted that the (Ag), because of its d shell electrons, subsist in dissimilar oxidation states and shapes. The method of formation of these oxides relies at the growth conditions/reaction kinetics, accessibility of (O2) in the growth chamber with the energy refrain to the oxidation. The surface morphology and the nucleation kinetics of the (Ag:O) pends the kinetic energy of the particles (Ag and O2 atoms) arrival to the substrate [7]. Amongst the varied metal, (Ag) denoted effective thermally conductivity, high electrically conductivity and can be combined into silver based composites with diverse compositions. Silver(Ag) remains further interactive than gold(Au) or platinum(Pt) so, Silver(Ag) is the furthermost suitable nominee for several applications [8, 9]. Silver oxide (AgO) thin film can be manufactured by usage several deposition methods such as thermally oxidation of silver (Ag)film [10], thermally evaporations [11], electron beams evaporations [12], laser pulse deposition [13].
In the current work, successful preparation of silver oxide by laser ablation in liquid and deposition of Ag thin film by drop casting method. The structural and optical characterizations of the AgO thin film was performed.

2. Experimental work

The laser used in the deformation process Nd: YAG works at a frequency of 10 Hz, with a pulse width of 7 ns and a 1064 nm wavelength. The laser pulses were focused on a 20 cm positive lens on a 2mm dry bulk sample from AgO (99.99% purity provided by Al-Shorfa) immersed in methanol at laser power (600 mJ) with 20-minute ablation time. The laser pulse energy was measured using a calibrated calorimeter after taking into account the effect of ethanol permeability. Agradometer (XRD 6000, Shimadzu, X-ray, refractometer) with Cukα radiation at wavelength (λ = 0.15405 nm was used) To investigate the structural properties of AgO nanoparticles NPs deposited on a glass substrate. AgO, NPs were measured using optical spectrometer (Cary, 100 plus box, UV-Vis-NIR, beam split optics, double detectors) in the 200-900 nm range. The morphology of the AgO NPs was investigated by using AFM (AA 3000 Scanning Probe Microscope). The film thickness was measured using the Angstrom sun Technologies Inc. All the above measurements were made at room temperature , (t) the film thickness: 200 nm, (m): the mass of material in gm, (d): the distance in cm between the object and the component holder, (ρ): the density of the substance .

XRD patterns of AgO anstructures diffraction peak absorb at (2θ) value .The distinct peaks are using to compute the crystal size by Scherrer’s equation [14]

\[ G = \frac{K \times \beta}{\cos \theta} \quad \ldots \ldots \quad (1) \]

(β= FWHM): is the half maximum of full width and (θ): angle of diffraction peaks, K: Scherrer constant (0.9) . The XRD study shows that the sample is face center cubic (FCC) silver thin films [15].

The microstrain (ɲ) and the dislocation density (σ) calculate using the following equations [15], as shown in the chart (1):

\[ \eta = \frac{\beta \cos \theta}{4} \quad \ldots \ldots \quad (2) \]
\[ \delta = G-2 \quad \ldots \ldots \quad (3) \]

From the absorbance values, near at the principal absorption edge, the absorption coefficient(α)was calculate in the area of powerful absorption using the relation below:

\[ \alpha = \frac{2.303 A}{t} \quad \ldots \ldots \quad (4) \]

3. Resultants and discussion

Figure 1 shows that the diffraction angles 43.16°,79.28° were attributed for (112) and (222) AgO samples. The crystal size Of polycrystalline structure miscalculated by using the Debye-Scherrer equation [14], and that the nanostructures develop with a randomized orientation [14-15].
Figure 1. XRD pattern of AgO film.

Table 1. shows the XRD parameters calculated for AgO thin film

| 2Theta (degree) | FWHM (degree) | G (nm) | strain x 10^{-4} lines m^{-2} | δ×10^{14} Lines/m^2 |
|-----------------|---------------|--------|-------------------------------|-------------------------|
| 37.2069         | 0.52          | 15.9267| 21.7983                       | 39.422887               |
| 43.1618         | 0.38          | 22.4181| 15.48631                      | 19.897517               |
| 79.2887         | 0.42          | 24.54873| 14.14228                      | 16.593656               |

Figure (2) and (3) explain the transmission and absorption spectrum on AgO thin film, these figures show that the optical transmission accomplish to 60% at (1100nm) wavelength and this characteristic to high transmission of nanoparticles at these wavelengths, then the transmittance increases with wavelength increases.

Figure 2. Optical transmittance of AgO thin films
The band gap was calculated from a plot of square ($\alpha hv$) versus $hv$ for AgO NPS the intercept of the straight line with $hv$ axis give the band gap ($E_g$) 3.5eV attributed to quantum confinement effect, as shown in figure (4).

Figure 5 explains 3D AFM pictures and Granularity accumulated distribution of AgO thin films prepared by deposited on a glass substrate. The substrate is fully encapsulated with AgO nanoparticle AgO NPS dispensed homogeneously on the surface. It is clear from this figure 5 that AgO NPS have small molecules arranged with hemispherical with some unipolar rods. Average particle size estimated with the help of Imager 4.62.
Figure 5. AFM picture of AgO thin film surface

The topography of the AgO thin film surface is investigated with optical microscopy. A digital camera with the microscope and connected to the computer in order to store the surface image of the prepared AgO layers. Computerize optical microscope provided with camera model Olympus BX 51n is used. The microstructure of AgO thin films was studied by using optical microscope. These images reveal that the Ag:In morphology can be simply recognized from films color and homogeneities. The surfaces are rough and have various colors, as shown in figure (6).

Figure 6. Micrograph of AgO thin film

4. Conclusion

This study has obviously presented how AgO samples growth laser ablation in methanol (easy, low cost, and quick technique to the combinations of AgO nanostructures). The deportment of the sample as illustrated in the figures obvious that the sample is a visible transmitting thin film with a good crystallize.

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