





The effects of solvent nature on spray-deposited ZnO thin film prepared from Zn (CH₃COO)₂ · 2H₂O

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Abstract

Transparent conducting zinc oxide was deposited on glass substrate by ultrasonic spray method. The ZnO samples with concentration of 0.1 M were deposited at 300, 350 and 400 °C with 2 min of deposition time. The effects of substrate temperature, ethanol and methanol solution on the structural, electrical and optical properties were examined. The DRX analyses indicated that ZnO films have polycrystalline nature and hexagonal wurtzite structure with (100) and (002) preferential orientation corresponding to ZnO films resulting from methanol and ethanol, respectively. The crystallinity of the thin films improved with ethanol solution. All films exhibit an average optical transparency about 80%, in the visible range. The band gap energy of ZnO films obtained with methanol solution higher than of ethanol solution for all the films. The electrical resistivity decrease with ZnO obtained from ethanol indicated; due to the maximum crystallite size reached at this point.

Introduction

The increasing demand for low-cost and high-performance optoelectronic devices motivates us to develop more efficient transparent conductive oxide (TCO) thin films. In the last decades, zinc oxide (ZnO) has emerged as one of the TCOs are widely used in microelectronic devices, light emitting diodes, thin films, antireflection coatings, transparent electrodes in solar cells [1], gas sensors surface acoustic wave devices [2], varistors, spintronic devices and lasers [3]. Zinc oxide (ZnO) is a very interesting semiconducting material with a wide and direct band gap of 3.4 eV at room temperature and a high exciton binding energy of 60 meV [4]. ZnO thin films can be produced by several techniques such as molecular beam epitaxy (MBE), chemical vapor deposition, electrochemical deposition [5], pulsed laser deposition (PLD), sol-gel process [6], reactive evaporation, magnetron sputtering technique and spray pyrolysis [7].

Although the ultrasonic spray method is especially efficient in producing thin films, transparent, multi-component oxide layers of many compositions on various substrates, including glass, there are still many factors affecting the physical properties of ZnO thin films. These factors include ZnO solution concentration,

solvent, substrate temperature, post-annealing temperature, annealing atmosphere and film thickness [8], [9], [10], [11], [12], [13]. The novel results derived from this situation have encouraged the researchers to increase their interest in the field of chemically sprayed ZnO thin films. This is the reason why we focus our attention mainly on the contributions on chemically sprayed ZnO thin films, otherwise we have prepared chemically sprayed ZnO by two different solutions are contains of ethanol and methanol solution.

In this paper, we have deposited ZnO samples on glass substrates by ultrasonic spray technique. The ZnO samples with concentration of 0.1 M were deposited at 300, 350 and 400 °C with 2 min of deposition time. We have studied the effects of ethanol and methanol solution and substrate temperature on the crystallinity, band gap energy and electrical resistivity of ZnO thin films.

Section snippets

Preparation of spray solution

ZnO solution were prepared by dissolving (0.1 M) zinc acetate-dihydrate Zn(CH₃COO)₂ · 2H₂O in the solvent containing equal volumes absolute ethanol and methanol solution (99.995%) purity, then have added a drops of HCl solution as a stabilized, the mixture solution was stirred an heated at 50 °C for 2h to yield a clear and transparency solution.

The substrate was R217102 glass in a size of 1 cm × 1 cm × 0.1 cm, prior to pumping, the substrate (R217102 glass) were cleaned with alcohol in an ultrasonic bath ...

Crystalline structure

Fig. 1 shows the XRD patterns of ZnO thin films deposited on glass substrate at a substrate temperatures of 350 °C, the films were obtained by using ethanol and methanol. Five diffraction peaks were observed at $2\theta = 31.8^\circ$, 34.5° , 36.4° , 47.1° and 57.50° which can be attributed respectively to (100), (002), (101), (102) and (112) planes of ZnO phase. This result showed the thin films were polycrystalline and had a hexagonal wurtzite structure. The obtained XRD spectra matched well with the space...

Conclusion

In conclusion, highly transparent conducting zinc oxide was deposited on glass substrate by ultrasonic spray method. The ZnO samples with concentration of 0.1 M were deposited at 300, 350 and 400 °C with 2 min of deposition time. The effects of substrate temperature and ethanol and methanol solution on the structural, electrical and optical properties were investigated. The DRX analyses indicated that ZnO films have polycrystalline nature and hexagonal wurtzite structure with (100) and (002)...

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[Spray pyrolysis deposition of ZnO thin films on FTO coated substrates from zinc acetate and zinc chloride precursor solution at different growth temperatures](#)

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2021, Optik

Citation Excerpt :

...Foo et al. probed the structural and optical properties of ZnO thin films by using four different solvents namely methanol, ethanol, isopropyl alcohol and 2-methoxyethanol and found that the thin films prepared by using 2-methoxyethanol has the highest transmittance (>90 %), lowest surface roughness (3.131 nm) and highest band gap energy of 3.26 eV in comparison to other solvents [13]. Similarly, Benramache et al. compared the effect of ethanol and methanol on the properties of ZnO thin films and showed that ethanol solution results lowest resistivity due to good crystallinity in comparison to films prepared from methanol solution [14]. The objective of this study is to investigate the combined effect of composition of solvent (methanol and de-ionized water) and Fe-In codoping concentration on structural, optical and electrical properties of ZnO thin films by using spray pyrolysis method....

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2020, Optik

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2019, Materialia

Citation Excerpt :

...The observed UV absorption is intense and attributed to the band-edge absorption by ZnO. The variation in band-tails suggests defects such as oxygen vacancies, interstitial Zn, and impurity-induced disorder in ZnO [37]. At lower seeding-angles, i.e. ZnO-0 and ZnO-30 samples show very feeble absorption in the visible region as compared to the other samples deposited at higher seeding-angle....

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2019, Physica B: Condensed Matter

Citation Excerpt :

...Control of number of deposition cycles, dipping time, drying time, temperature and pH value of precursor solution help in forming a good quality nanostructured thin film. ZnO is a potential candidate for various commercial applications such as integrated optics, antireflection coatings, displays, UV detectors, light emitting diodes, chemical sensors, solar cells, transistors, super hydrophobic and self-cleaning surfaces, photo degradation & photo catalysis etc. [19–26]. Among them, chemical sensor is a better application [27–33] due to its highly ionising nature, which involves many chemical processes [34]....

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2017, Materials Science in Semiconductor Processing

Citation Excerpt :

...Due to their unique properties, ZnO is a promising semiconductor material for wide variety of applications. ZnO is an n-type semiconducting material and it possesses a hexagonal wurtzite structure, which is generally used in different commercial applications such as integrated optics, antireflection coatings, displays, UV detectors, lightemitting diodes, chemical sensors, solar cells, transistors, superhydrophobic and self-cleaning surfaces, photodegradation and photocatalysis etc. [1–4]. Zinc oxide thin films have been developed with number of synthesis techniques such as electrochemical deposition [2], pulsed laser deposition [3], spray pyrolysis [4], SILAR [5], chemical bath deposition [6], RF magnetron sputtering [7], hydrothermal method [8], and the sol–gel method [9]...

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