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Preparation and Characterization of Nickel Oxide Thin Films: A review

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Abstract

Abundant literature is available on the preparation and characterization of metal oxide films as described by many researchers. Generally, physical and chemical deposition techniques could be used to prepare NiO films on various substrates. The obtained films will be studied using different tools such as x-ray diffraction, scanning electron microscopy and UV-Visible spectrophotometer in order to determine the best experimental conditions.

Keywords: nickel oxide, thin films, chemical bath deposition, band gap, spray pyrolysis.

INTRODUCTION

In recent years, fabrication of nanometer to micrometer scale metal chalcogenide films (1-34) and metal oxide films (35-38), is of great interest to material chemists. This is due to their applications such as semiconducting devices, solar cells, optoelectronic devices, radiation detector, laser materials and thermo electric devices.
In this work, nickel oxide films were prepared using several deposition methods. These materials have a wide band gap. Furthermore, they have excellent durability and electrochemical stability with a large range of optical densities. The nickel oxide films will be prepared under various deposition conditions. Then, the influence of these conditions on the properties of films will be investigated using x-ray diffraction (XRD), scanning electron microscopy (SEM), and UV-visible spectrophotometer.

LITERATURE SURVEY

Nanostructured nickel oxide thin films have been prepared using several deposition methods as reported by many researchers. The experimental results have been analyzed and discussed under various deposition conditions as described in many literature reviews.

Ismail et al. (39) have reported the NiO films using spray pyrolysis method in the presence of nickel chloride salt solution. The films were deposited onto various substrates such as glass and silicon at various temperatures such as 280, 320, 360 and 400 °C. They reveal that the deposited films at 280 °C have amorphous structure as shown in XRD studies. However, the films show cubic structure at higher temperatures.

NiO films were prepared by sol gel method as described by Jlassi et al (40) under various annealing temperatures. The nickel acetate tetrahydrate and monoethanolamine was used as precursor and catalyst during the experiment. The XRD analysis reveals that all annealed films have polycrystalline structures. Meanwhile, as-deposited films display a single broad unstructured XRD line. The predominant peak corresponding to (200) could be observed. The intensity of this peak increases as the annealing temperature was increased from 300 to 600 °C. On the other hand, it is clear that all the films show high transparencies in the visible and near Infrared portions as the annealing temperature increases. In other words, they conclude that the annealing temperature of 600 °C was the best conditions, which resulting in films with good transmittance.

NiO films were prepared using nickel chloride solution onto glass substrate at 350 °C by Patil & Kadam (41).They found that the films were gray in colour and strongly adherent to the substrate. The influence of volume of sprayed solution on the properties of films was reported. They observe that the thickness and grain size were varied from 0.028-0.23 µm, and 14-17 nm, respectively as the volume of sprayed solution was increased from 30 to 75 ml. In another case, the band gap changes from 3.58 to 3.4 eV with increase in the film thickness. They explain that may be attributed to the changes in homogeneity and crystallinity of the films.

NiO films were prepared using fresh and aged precursor solutions using spray pyrolysis method as proposed by Sriram & Thayumanavan (42). The XRD studies indicate that the films prepared from aged solution (60.3 nm) have larger grain size as indicated in SEM studies compared to the film prepared from fresh solution (21 nm).In optical studies, higher band gap could be obtained for the films prepared without aging precursor (3.6 eV). In other words, the grain size is increased because of aging effect and hence, leads the decreasing band gap (3.5 eV).

Thin films of NiO were deposited on glass substrate using chemical bath deposition method as reported by Ezema et al (43). Ammonia and nickel chloride were used as complexing agent and precursor, respectively during the experiment. The optical studies show that the band gap increased from 2.1 to 3.9 eV as the anneal temperature was increased from 300 to 473 K.It means that nickel oxide films are wide band gap semiconductor material. The obtained band gap values are in excellent agreement with reported values for NiO films as described by Gomaa et al (44), Venter & Botha(45) and Han et al. (46). Also, they point out that the films prepared at 423 K and 473 K have transmittances more than 72% in the Visible and near infrared regions. On the other hand, Osuwa & Onyejiuwa(47) have reported that the NiO film thickness reduced with annealing temperature from 1.4 µm for as-grown to 0.75 µm for films deposited at 300 °C.

NiO films were prepared using dc reactive magnetron sputtering method by Reddy et al (48). Scanning electron microscopy micrographs of the NiO films as a function of thickness were present by them. The films deposited at the thickness of 150 nm show irregular shape grains. However, uniform grains size distribution and larger grain size can be seen at the films thickness of 250 nm. The worm like structure was observed as the films deposited at 350 nm thickness. Further, smaller grain and smooth structure could be obtained at the film thickness of 550 nm. In another case, the effect of oxygen partial pressure on the properties of NiO films was investigated by Zhao et al (49). The XRD patterns show that the intensity of (200) peak increases when the oxygen partial pressure increases from 0% to 80%. The morphology study reveals that the films were smooth, dense and homogeneous at oxygen partial pressure below 60%. However, the cracks increased with increasing oxygen partial pressure from 60 % to 80 %. In other words, it can be seen that excessive oxygen gas would destroy the integrality of the films.

In future, more metal oxide thin films should be investigated by researcher. The characteristics of these films should be carried out by using other equipments such as Energy dispersive analysis of X-ray, atomic absorption spectrometry, transmission electron microscopy, scanning probe microscopy, surface profiler and X-ray photoelectron spectroscopy. Besides that, the electrical properties and conductivity measurement should be analyzed in order to obtain good quality of thin films.

CONCLUSION

Nickel oxide thin films have been successfully deposited by many researchers using various deposition techniques. The structure, morphology and optical properties could be studied using XRD, SEM and UV-Visible spectrophotometer, respectively. According to experimental findings, nickel oxide films were wide band gap in the range of 2.1 to 3.9 eV. Scanning electron microscopy studies indicate that a strong dependence of the surface texture and grain size on the various experimental conditions.

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