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Deposition and Characterization of Zinc Oxide Films

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Abstract: Zinc oxide (ZnO) is suitable for optoelectronic applications due to its electrical and optical properties. The present work deals with the preparation and characterization of ZnO films deposited by the ultrasonic spray pyrolysis method. The starting solution was zinc acetate. Effects of substrate temperature on films properties have been investigated. Optical properties of the films have been characterized by investigating transmittance, absorbance and photoluminescence (PL) spectra. Optical transmission spectrum shows that ZnO films have high transmission (about 80%) in visible region for substrate temperatures at 350^{o}C. Surface morphology of the films has also been analyzed by atomic force microscope (AFM). Four probes conductivity measurements have been used for electrical characterization. The resistivity of ZnO films increases with increasing substrate temperatures

Çinko Oksit Filmlerinin Üretim ve Karakterizasyonu

Anahtar Kelimeler
ZnO
AKM
Fotolüminesans
Spektrum(PL)

Özet: Çinko oksit (ZnO) elektriksel ve optik özellikleri sebebiyle optoelektronik uygulamalar için uygun bir malzemedir. Bu çalışma, ultrasonik kimyasal püskürtme tekniği ile çöktürülen ZnO filmlerinin üretim ve karakterizasyonu ile ilgilidir. Filmlerin bazı özellikleri üzerine taban sıcaklığının etkisi araştırılmıştır. Filmler geçirgenlik, soğurma ve fotolüminesans spektrumları ile karakterize edilmiştir. Optik geçirgenlik spektrumu, 350^{o}C taban sıcaklığı için görünür bölgede yüksek geçirgenlik değerlerine (yaklaşık %80) sahip olduğunu göstermektedir. Filmlerin yüzey morfolojileri atomik kuvvet mikroskobuyla (AKM) analiz edilmiştir. Elektriksel karakterizasyon için dört uç iletkenlik ölçümleri kullanılmıştır. ZnO filmlerinin özdirenç değerleri artan taban sıcaklığıyla birlikte artış göstermiştir.

1. Introduction

ZnO has received great interest owing to its wide band gap (3.3 eV), transparency, electrical and piezoelectrical properties. Moreover, ZnO is a cheap, abundant, chemically stable and non-toxic material that has been widely used in optoelectronic devices, photovoltaic devices and surface acoustic wave devices and sensors. Many techniques have been used for depositing high quality ZnO thin films. Some of them are pulsed laser deposition [Mohanty, 2013], RF sputtering [Ghafouri, 2012], chemical solution deposition [Wang 2009, Vayssieres 2003], electron beam evaporation [Qiu, 2004], the sol–gel method [Vishwas, 2012] and spray pyrolysis [Zahedi 2011, Rozati 2011].

2. Experimental Parameters

In the present work, zinc oxide thin films were prepared on 1cm×1cm glass substrates at 300±5 °C and 350±5°C using ultrasonic spray pyrolysis technique, which is an effective method for the large

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area deposition of thin films of metallic oxides. Physical characteristics of the samples can be controlled through appropriate variation of deposition parameters. Zinc acetate solution (0.2 M) was prepared in a mixture of methanol and water, taken in the volume ratio 3:1. Addition of few drops of acetic acid prohibits the precipitation of zinc hydroxide, thereby making the spray solution clear and producing films of better optical transmittance. The glass substrate was cleaned in ethanol, rinsed in deionised water. A flow rate of the solution fixed 5 $ml.min^{-1}$ and totally, 100 ml of solution was used.

The optical measurement of ZnO thin film was carried out at room temperature using Shimadzu UV-VIS-2450 spectrophotometer in the wavelength range from 300 to 900 nm.

PL spectra at room temperature were measured in the range of 350–600 nm. Surface morphology of the ZnO films was investigated using a PARK system XE 100 atomic force microscopy (AFM).

3. Results and Discussions

The transmittance spectra of deposited films are shown in Fig. 1. We note that the films are transparent in the visible region. With increasing substrate temperature optical transmission reaches a maximum value for 78% for film at 350 °C. At long wavelengths, transmission exhibit oscillation from interference effects in the transparent film.

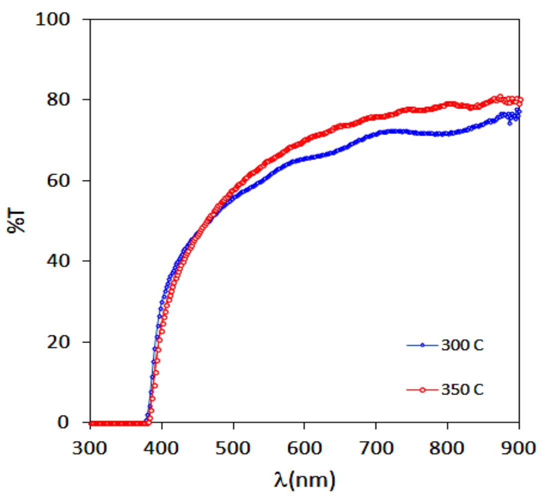

Figure 1. Transmission spectra of the ZnO films for different substrate temperatures as function of wavelength.

Fig. 2 shows the room temperature PL spectra of ZnO films. It is found that the spectra of all the samples similarly show emission bands. The blue-green emission at about 460nm and the yellow emission at about 530nm are probably ascribed to surface deep traps or intrinsic defects such as Zn interstitials and oxygen vacancies.

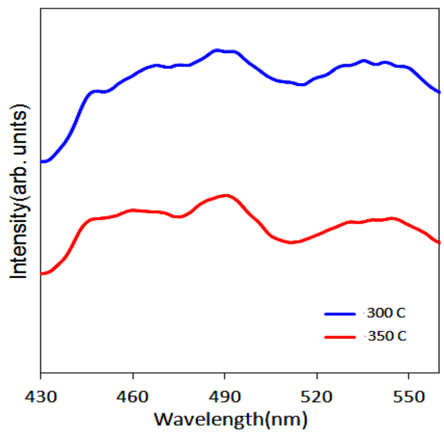

Figure 2. Photoluminescence spectra for ZnO films grown at different substrate temperatures.

The morphology of the ZnO films has been investigated using atomic force microscopy. It was observed that the surface roughness of the ZnO films decreases with increase in substrate temperature. All the images were taken in 5 μm x5 μm area. As observed in Fig. 3, ZnO films are different in morphology.

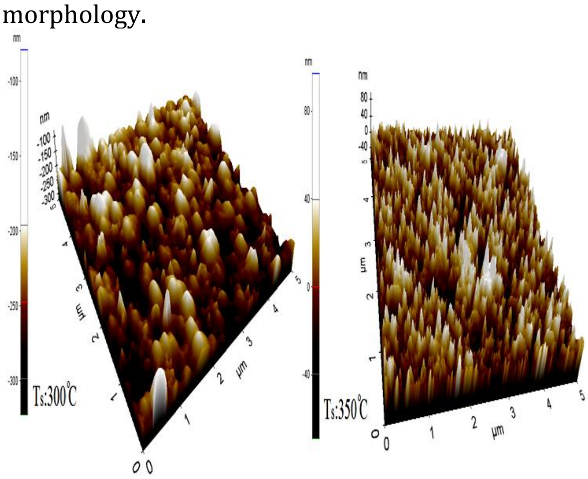

Figure 3. AFM images of ZnO films grown at different substrate temperatures.

4. Conclusions

Transparent conducting ZnO films were prepared and characterized in order to study their electrical, surface and optical properties. With increasing substrate temperature, optical transmission reaches a maximum value. A similar behavior in flor-doped ZnO thin films has been reported by Olvera et al [Olvera, 2001]. Due to interference of the films, transmission curves showed fluctuations and wave-like patterns. A similar case was observed in other researchs [Olvera, 2001]. The optimum ZnO thin films were obtained in the substrate temperature range of 350±5 °C. The resistivity and the transmittance values obtained in our films deposited under optimum conditions, become them in good candidates for potential application in thin film solar cells.

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