College Name- Gramin Mahavidyalaya, Vasantnagar College Code-117

Admission Fee of M. Com F.Y. (Annual Pattern)(External Education) For the Year 2021-22

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Deposition and Structural & Electrical Characterization of Nanostructured ZnO Thin films by Chemical Spray Pyrolysis Technique

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Abstract :

ZnO thin films were deposited by Chemical Spray Pyrolysis technique. The substrate temperature was maintained at 400°C for uniform deposition of thin film. The pH of the solution and morality were controlled for uniform spray on to heated glass substrate. The transparent white colored thin films were annealed in air atmosphere at 450°C for the betterment oxidation of ZnO material. As deposited an annealed films were characterized using the XRD. The films have uniform morphology with uniform grains distribution throughout the substrate. The electrical properties were studied using four probe method. Plots of Log ρ vs (1000/T) for various substrate temperature at constant 0.2M concentration show that The dependence of log of electrical resistivity with reciprocal of temperature is nonlinear due to the irregular grain boundaries and large spacing between them (defect states). The other studies reveal that the ZnO thin films are more useful for optoelectronic applications.

Introduction:

Zinc oxide (ZnO) has been of considerable interest to the optical and electrical industries, because of its electrical optical and acoustic characteristics . ZnO thin films are of great interest for applications like optoelectronic devices such as lasers modulators and optical switches and photovoltaic applications [1-4]. Many techniques have been employed to prepare ZnO thin films such as RF magnetron sputtering [5], sol-gel [6], DMSO chemical bath [7] and spray pyrolysis [8]. The spray pyrolysis technique is considered as a useful method for large area deposition due to the low cost and simplicity of the apparatus. In the present work polycrystalline wurtzite zinc oxide thin films were deposited by spray pyrolysis technique using aqueous and nonaqueous solution of zinc acetate. The preparation of oxide thin films by spray pyrolysis from an aqueous solution presents several advantages over the above techniques. In the present work highly transparent and conductive Zinc oxide thin films were prepared by spray pyrolysis technique at different substrate temperatures using a precursor solution of Zinc acetate. The wide bandgap properties of semiconductors, such as Zinc oxide are conducting, transparent in the visible region with a wide direct bandgap of 3.30 eV at room temperature.

Experimental:

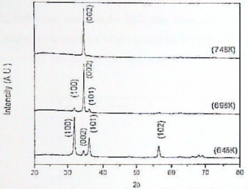
Zinc oxide (ZnO) thin films were deposited by spraying an aqueous solution of zinc acetate 0.2M on a heated glass substrate. The substrate temperature was kept at constant temperature within the range 648-748K with an accuracy of ±5K. Compressed air was used as a carrier gas and spray rate was maintained at 5ml/min. The nozzle to substrate distance was kept 25cm apart. To enhance the conductivity deposited films were annealed at 375K for 60 min. The films from acetate solution having molarity 0.1,0.3 and 0.4 were also prepared at optimum substrate temperature without changing other preparative parameters. The apparatus and deposition details have been already reported. Characterization of ZnO thin films was carried out using PHILIPS X-pert PRO model X-Ray diffractometer. The electrical studies were carried out using four-probe technique and using SHIMADHZU 160-A model..

Result and discussion:

XRD analysis:

Fig 1 shows the X-Ray diffraction pattern of Zinc oxide thin films prepared by spray pyrolysis technique at different substrate temperature using an aqueous solution having molarity 0.2M of zinc acetate. All the peaks in this diffraction pattern indicates polycrystalline nature, which corresponds to hexagonal wurtize structure of ZnO films with prominent diffraction from crystal planes like (002), (101), (100) and (102) at

648K These peaks are indexed on the basis of JCPDS data card 5-0664. The preferential orientation was along (002) plane. The calculated values of lattice constant are found to close that of JCPDS data reported for ZnO powder sample. The peak intensity ratio (I_{hkl} / I_{max}) gives the measure of preferential orientations in the films. The strongest peak corresponds to (002) plane indicating that most grains have c-axis perpendicular to the surface. The peak intensity of (002) plane increase as the substrate temperature increases.



ZnO deposited by Spray pyrolysis at various substrate temperature

Electrical Resistivity:

The variation of log of electrical resistivity (log ρ) with reciprocal of temperature (1000/T) of ZnO thin films for various substrate temperatures at a constant 0.2 M concentration is shown in following figure. In each case it was observed that the electrical resistivity (ρ) decreases as temperature (T) increases, indicating the semiconducting nature of thin films. The decrease in electrical resistivity was due to the improvement in crystallinity of thin films, which would increase the charge carrier mobility. Similar results have been reported having the same behavior of nanocrystalline materials prepared by different methods [9-10]. The spray deposited ZnO thin films possess higher electrical resistivity may be due to its nanocrystalline nature of the films. Nair et al [11] have reported the same results for chemically prepared CdSe thin films.

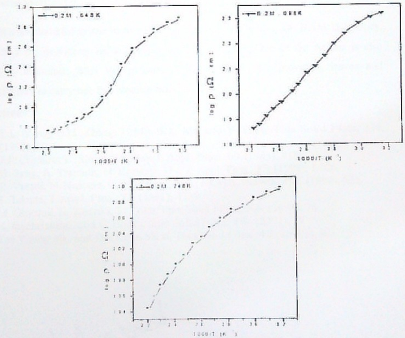
Following figure shows the variation of log of resistivity with concentration, which gives similar results as discussed earlier.

The dependence of log of electrical resistivity with reciprocal of temperature is nonlinear due to the irregular grain boundaries and large spacing between them (defect states). The activation energy was calculated from the linear portion of the change in log of electrical resistivity with the reciprocal of temperature using the relation

$$\rho = \rho_0 \exp(-Ea / 2kT)$$

Where the symbols have their usual meanings

The activation energies for ZnO thin films vary from 0.030 to 0.82 eV with the decrease in molar concentration of the precursor solution of Zinc acetate. These energies represent the average energies of carriers, which can move at the bottom or top of the well-defined band.



Plots of Log ρ vs (1000/T) for various substrate temperature at constant 0.2M concentration.

Conculsion:

ZnO thin films were deposited on heated glass substrates by low cost spray pyrolysis technique. The XRD patterns show a polycrystalline nature with Wurtzite crystal structure. The electrical resistivity was carried out for a temperature range 315 – 545 K. The electrical resistivity decreases as the temperature increases. It shows n type conductivity. The dependence of log of electrical resistivity with reciprocal of temperature is nonlinear due to the irregular grain boundaries and large spacing between them (defect states). The activation energy was calculated from the linear portion of the change in log of electrical resistivity with the reciprocal of temperatures, which was obtained for ZnO thin films for conduction varies from 0.46 to 1.16 x 10^{-2} eV.

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