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Electrical Conductivity of Surface Activated Nanostructure ZnO-Al_2O_3 Thick Films

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Abstract: Zinc Oxide particles were synthesized by Chemical Precipitation Method. The average particle size of ZnO is found to be 19 nm. Thick films of ZnO were prepared by screen printing technique and Al_2O_3 -surface activated ZnO films were prepared by dipping method. The variation of electrical conductivity of pure and surface activated films was studied with temperature. The results of electrical measurement at the room temperature show that, pure ZnO and surface activated thick films are semiconducting in nature. The decrease in conductivity of surface activated thick films may be due to presence of potential barrier at the intergrain boundaries of ZnO-Al_2O_3 and hence the grain boundary region becomes more resistive.

Keywords: ZnO, Chemical Precipitation Method, XRD, Surface activated ZnO- Al_2O_3 thick film, Electrical conductivity.

I. INTRODUCTION

Today, when the world is prevailing on the roof of technology and electronics, mostly dominated by compatible electronic equipments and thereby creating the need for materials possessing useful properties. The world now demands a material that should possess inherent properties like larger band gap, higher electron mobility as well as higher breakdown field strength. So on making investigation about such a material the name of compound comes out is “Zinc Oxide” which is a wide gap semiconductor material very well satisfying the above required properties.Zinc oxide possessed many versatile properties for UV electronics, spintronic devices and sensor applications. This ignites many research minds all over the world and creates interest to develop proper growth and processing techniques for the synthesis of Zinc oxide. The electrical, optical, magnetic, and chemical properties can be very well tuned by making permutation and combination of the two basic structural characteristics that is cations with mixed valence states, and anions with deficiencies(vacancies). Thus, making them suitable for several application fields such as semiconductor, superconductor, ferroelectrics, magnetic and gas sensing. Nanostructured materials such as ZnO, SnO_2, and WO_3 have shown good electrical properties [1-12]. Among these nanostructure-semiconducting materials, ZnO has been studied extensively for electrical application. Due to its versatility and multifunctionality creates attention in the research field related to its electrical applications. A wide number of synthesis techniques also been developed by which ZnO can be grown in different nanoscale forms. Efforts were made to synthesize ZnO nanostructure with innovative morphology by chemical route method. The synthesized ZnO shows good electrical conductivity. In the present work, the efforts are made to study electrical conductivity with a low cost additive (Al_2O_3) using dipping technique which is a simplest method of surface modification.

II. EXPERIMENTAL

A. *Synthesis of ZnO Nanostructure*

All chemicals were of analytical grade and used as purchased without further purification. In present work, Zinc nitrate hexahydrate was dissolved in distilled water such that to make 0.15M solution. Subsequently, 0.5 M NaOH aqueous solution was introduced into the above aqueous solution drop by drop with constant stirring. The resultant white solution was subsequently kept at 75 ^{0}C For 12 hrs.and then cooled room temperature naturally and sonicated (Ultrasonic wave treatment) for 30 min. The resulting white precipitates were collected by centrifugation, washed with distilled water and ethanol several times and then dried at 80^{0}C in vacuum oven for 2hr. Obtain ZnO nanostructure product were used for further study.

B. *Preparation of Thick Films*

Thick films of synthesized nanostructure ZnO were prepared by using screen printing technique. In present process, thixotropic paste was formulated by mixing the synthesized ZnO powder with ethyl cellulose (a temporary binder) in a mixture of organic solvents such as butyl cellulose, butyl carbitol acetate and turpineol. The ratio of ZnO to ethyl cellulose was kept at 95:05. The ratio of inorganic to organic part was kept as 75:25 in formulating the pastes. The thixotropic pastes were screen printed on a glass substrate in desired patterns. The films prepared were fired at 500°C for 12 hr. Prepared thick films were called as pure ZnO thick films.

III. MATERIALS CHARACTERIZATION

A. Thickness Measurement

Thickness of all ZnO thick films were measured by using technique “Marutek film Thickness Measurement System” with the help of provided equipment. The thicknesses of all films were observed in the range from 31 to 35 µm. Thick films of approximately uniform thick-nesses were used for further characterization.

B. X-Ray Diffraction Studies

The crystallographic structure of the synthesized ZnO nanostructure was characterized by powder X-ray diffraction (Philips X-ray diffractometer) with Cu-α source and 2θ range of 10° - 70°. Fig 1shows the XRD pattern of the ZnO nanostructure. The recorded XRD pattern confirmed that synthesized ZnO are highly crystalline in nature. The corresponding X-ray diffraction peak for (100), (002), (101), (102) (110), (103) and (112) planes confirm the formation of hexagonal wurtzite structure of ZnO (JCPDS card no.-01-080-0075). The domain size of the crystal can be estimated from the full width at half maximum (FWHM) of the peaks by means of the Scherrer formula,

$$D = \frac{k\lambda}{\beta sin\theta}$$

whereλ is the wavelength of incident beam (1.5406 Å), β is the FWHM of the peak in radians, θ is the diffraction angle and K is Scherrer constant. The average particle size was calculated from (101) peak ZnO is found to be 19 nm.

Using X’pert High Score Plus software it is confirm that synthesized zinc oxide powder contains Zn and O elements only, not any impurity and another element.

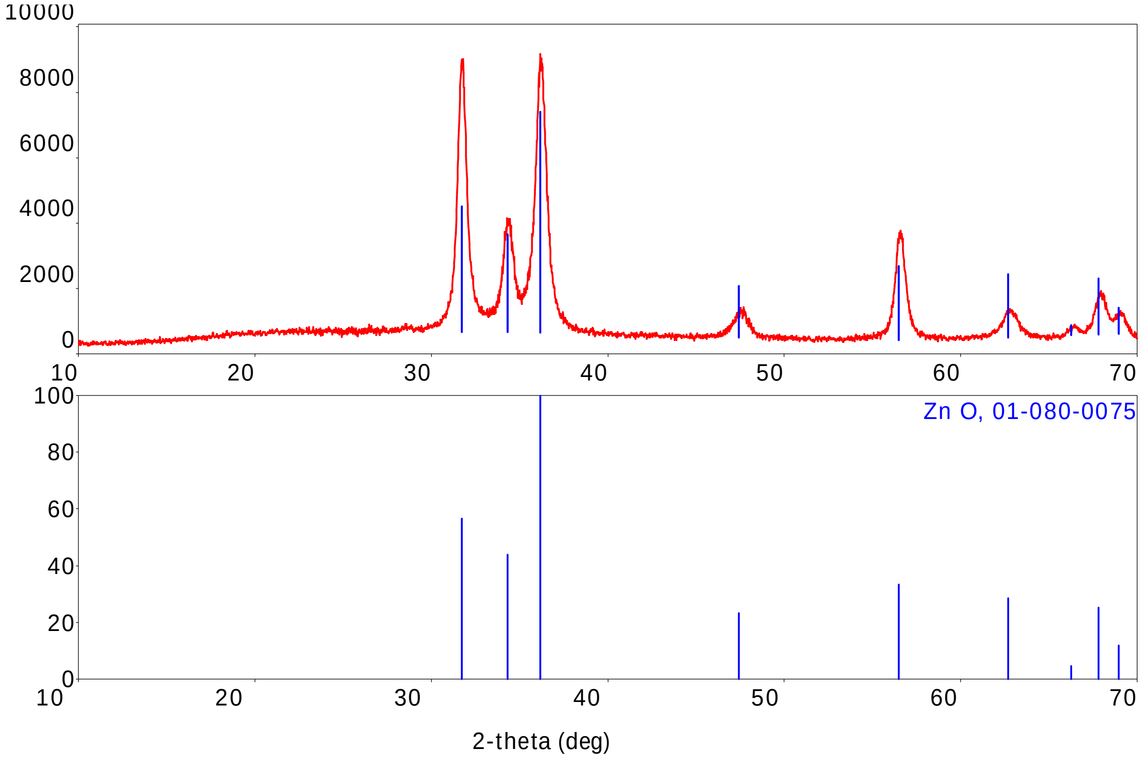

Fig1:XRD Pattern of Pure ZnONanostructure

IV. SURFACE MODIFICATION OF ZNO THICK FILM

The pure ZnO thick film was surface activated by dipping it into a 0.01M aqueous solution of Aluminium chloride anhydrous [$Al(H_2O)_6Cl_3$] for 2 min and was dried at 90^0C, followed by firing at 500^0C for 12 h in ambient air. The particles of Aluminum chloride dispersed on the film would be transformed to Aluminum oxide (Al_2O_3) during firing process.This surface-activated filmis termed as Al_2O_3-activated film. Silver contacts were made by vacuum evaporation for electrical measurements

V. ELECTRICAL PROPERTIES

A. *I–V characteristics*

Fig. 2depicts the I–V characteristics of the pure and Al_2O_3-activated ZnO films at room temperature. The symmetricalnature of I–V characteristics shows that silver contacts on the film are ohmic in nature[13].

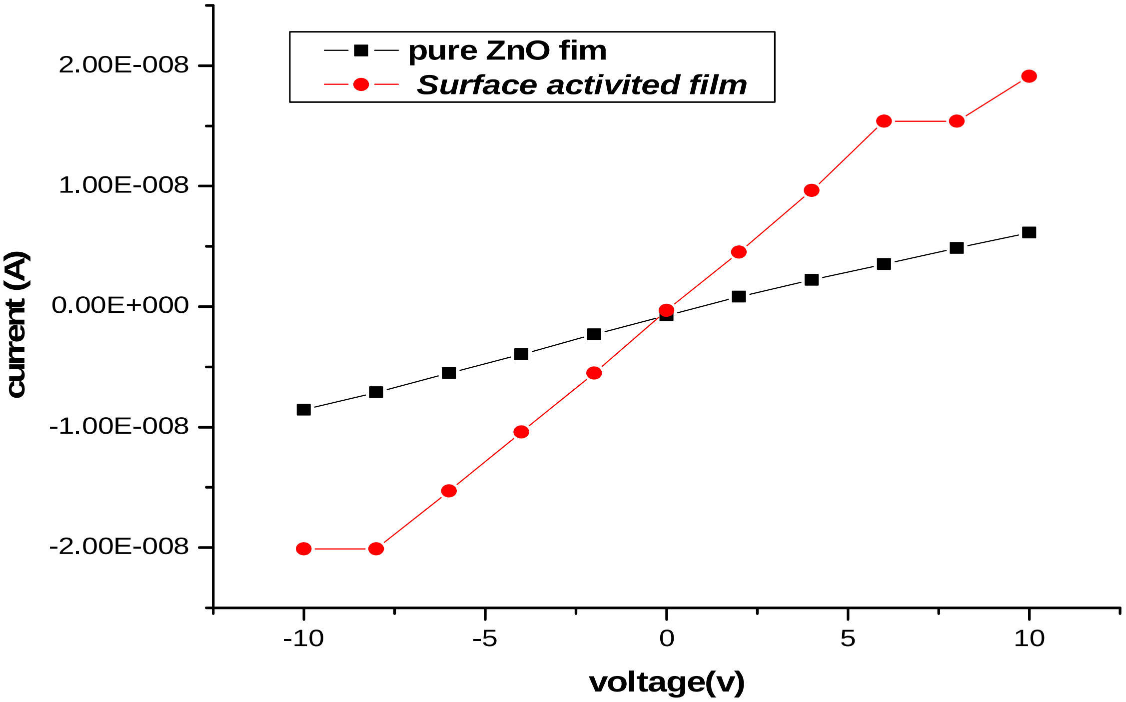

Fig 2:I-V Characteristics of pure ZnO and surface activatedthick film at room temperature

B. *Effect of Temperature on Current*

Fig. 3 shows the variation of current with temperature. The current values of all samples increase with operating temperature which shows good conduction in given samples.

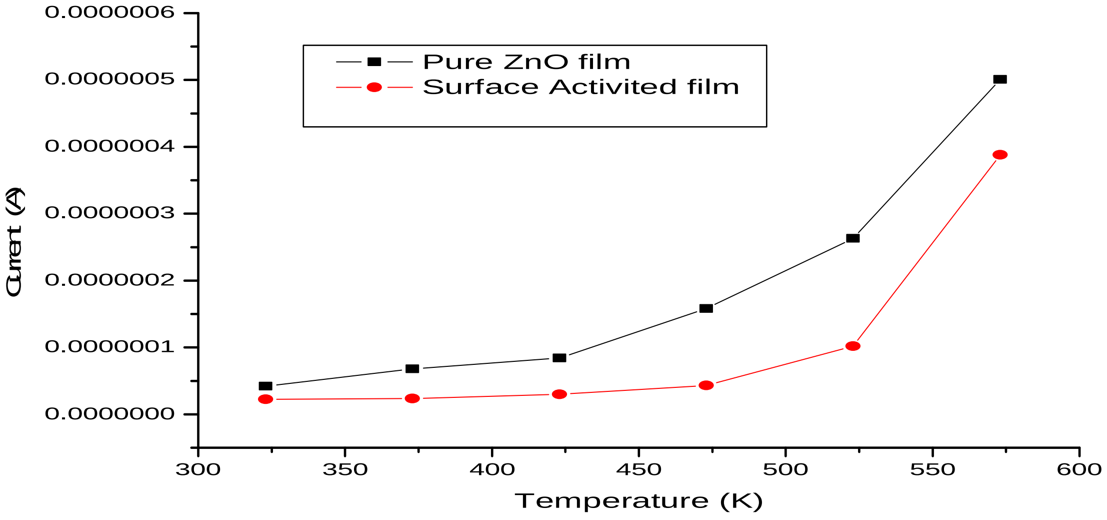

Fig 3: Variation of current with temperature

C. Electrical Conductivity

Fig. 4shows the variation of log σ (conductivity) with reciprocal of temperature of pure and activated films.The conductivity values of all samples increase with increasingtemperature. They are nearly linear to 1000/T in the range from 100 to 250^0C. The increase in conductivity with increasing temperature could be attributed to the negative temperature coefficient of resistance and semiconducting nature.

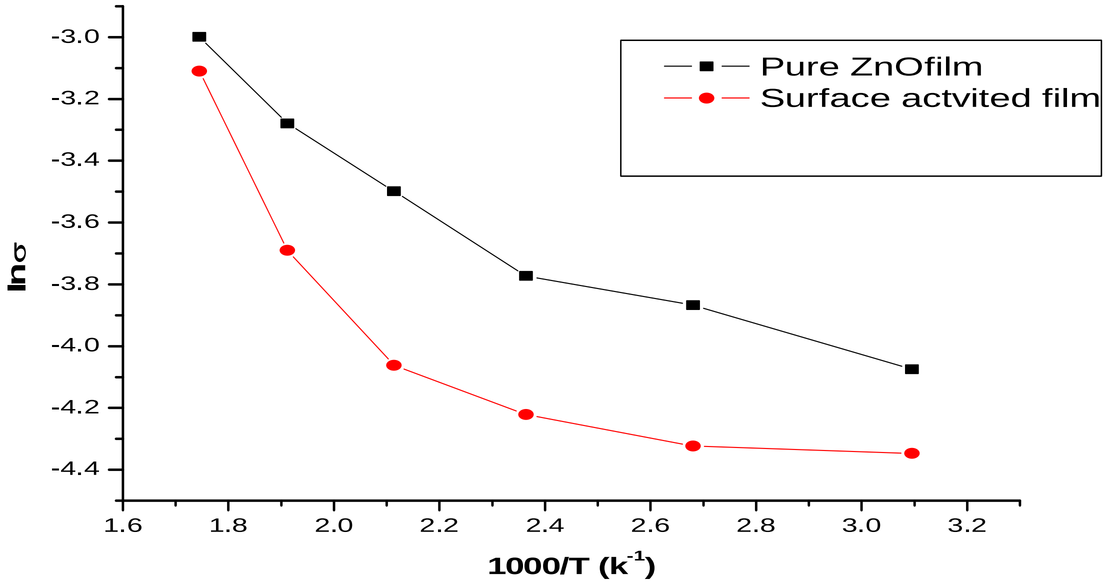

Fig 4: Variation of conductivity with reciprocal of temperature

VI. DISCUSSION

Increasing in conductivity with temperature of ZnO may be due to large oxygen deficiency which could adsorb oxygen species at higher temperature. The adsorption phenomena of the Al_2O_3 modified ZnO thick film surface may be different form the pure ZnO thick films surface. The Al_2O_3 misfits on the surface are the places where the oxygen species adsorb. The Al_2O_3 misfits distributed evenly on the surface would have made it possible to adsorb the oxygen ions even at low temperature. [14] Form fig 4 it is clear that conductivity of pure and Al_2O_3- modified ZnO films increases with an increase in temperature, indicating a positive temperature coefficient of conductance. This behavior confirmed the semiconducting nature of the pure and modified ZnO [15].

It is observed from fig 4 that the electrical conductivity of the pure ZnO film is higher than modified ZnO film in ambient air. It may be due to the intergranular potential barrier [14]. Pure ZnO has only one kind of grains arranged uniformly, where in the case of Al_2O_3 modified films the grains are of different natures such as Al_2O_3 and ZnO. The modification causes the formation of heterogeneous intergrain boundaries of the Al_2O_3-ZnO. Thus increased barrier heights of the intergranular regions of activated ZnO may be responsible to decrease the conductivity.

VII. SUMMARY

Thick filmsof ZnO nanostructureswere synthesized by a chemical precipitation method followed by sonication and their electrical properties were measured. The results demonstrated that the electrical conductivity of the pure ZnO film is higher than modified ZnO films in ambient air. Such nanomaterials with innovative structure can be used for future work such as gas sensing area.

REFERENCES

[1] S. Pizzini, N. Butta, D. Narducci, M. Palladina, J. Electrochem. Soc., 136,(7), (1989), 1945-48.
[2] H.W. Ryu, B.S. Park, A.A. Sheikh, W.S. Lee, K.J. Hong, Y.J. Seo, D.C. Shin, J.S. Park, G.P. Choi, Sensors and Actuators B, 96, (2003), 717-722.
[3] S.T. Shishiyanu, T.S. Shishiyanu, 0.1. Lupan, Sensors and Actuators B, 107, (2005), 379-386.
[4] Can Li,Shunping Zhang, Mulin Hu, ChangeshengXie, Sensors and Actuators B, 153,(2011),415-420.
[5] M.C.Carotta,A.Cervi,v.di.Natale, Sensors and Actuators B, 137,(2009),164-169.
[6] M.Hubner, N.Barsan, U.Weimar, Sensorsand Actuators B,151,(2010),103-106.
[7] M.Hubner, D.Koziej, M.Bauer, M.D.Rossell, AngewandteChemie-International Edition 50, (12), (2011) 2841-2844.

[8] Z. A. Ansari, Taegyung G. Ko, and Jae-Hee Oh, IEEE Sensor Journal, 5, (5), (2005), 817-824.
[9] G. Neri, A. Bonavita, G. Rizzo, S. Galvagno, N. Pinna, M. Niederberger, S. Capone, P. Siciliano, Sensor and Actuators B, 122 (2007) 564-571.
[10] M.D. Antonik, J.E. Schneider, E.L. Wittman, K. Snow, J.F. Vetelino, R.J. Lad, Thin Solid Films, 256 (1995) 247-252.
[11] V. Khatko, E. Llobet, X. Vilanova, J. Brezmes, J. Hubalek, K. Malysz, X. Correig, Sensor and Actuators B, 45 , (2005),111-112.
[12] W. Belkacem, A. Labidi, J. Guerin, N. Mliki, K. Aguir, Sensor and Actuators B, 132 (1),(2008), 196-201.
[13] G. H. Jain, M.S. Wagh, Sensors and Actuators B 123, (2007), 233-239.
[14] D. R. Patil, L.A. Patil , Sensors and Actuators B 123, (2007), 546- 553.
[15] KiCheol Park, Dae Young Ma, Kun Ho Kim, Thin solid films,305, (1997), 201-209.