International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST52310526

D. C. Electrical Conductivity of Ga doped ZnO

N. R. Thakare*[1], V. R. Chinchamalatpure[2]
[1]Department of Physics. P R. Pote Engineering. College Amravati, India
[2]Department of Physics Hutatma Rashtriya Arts and Science College, Ashti, Distt: Wardha, India
Corresponding Author Email: nilesh_thakarey@rediffmail.com

ARTICLEINFO

Article History:

Accepted: 07 Sep 2023
Published: 19 Sep 2023

Publication Issue
Volume 10, Issue 5
September-October-2023
Page Number
132-135

ABSTRACT

Doped ZnO is seen as a potential substitute to the expensive Sn doped material, as a transparent electrode in optoelectronic devices. Here, highly conductive and transparent Ga doped ZnO were prepared by chemical vapor deposition. The lowest resistivity and highest carrier concentration ever reported for CVD grown ZnO, Ga was achieved due to using oxygen poor growth conditions enabled by diethylzinc and triethylgallium precursors.
Physical properties like Electrical Conductivity of Zinc Oxide (ZnO) are studied with different doping in it. The dopant to study the varying physical properties of the ZnO semiconductor with respect to Gallium (Ga) semiconductor with changing doping by weight percent of0, 1, 3 and 5 wt. % gallium doped ZnO system are reported here. The electrical properties include dc electrical studies.
Keywords: D.C. Electrical Conductivity, ZnO

I. INTRODUCTION

Zinc oxide (ZnO) is a large bandgap semiconducting material with optoelectronic properties that is often used as a transparent conducting oxide in photovoltaic devices and are materials that display both high visible light transparency and low electrical resistivity, visible light transmittance, which is comparable to commercially available and widely used. The achievement, for the first time, of such low resistive ZnO: Ga doped is important as an ambient pressure, scalable and highly tunable technique that has industrial importance used for the fabrication of wide variety of thin film materials.

Semiconducting metal oxides are widely used as inexpensive and robust sensor material for toxic, hazardous and combustible gases and vapors in safety and automotive applications. Few semiconducting metal oxide materials used in these applications are ZnO, SnO_2, In_2O_3, Fe_2O_3, NiO, etc [1-11]. of which, zinc oxide (ZnO), an n-type semiconductor that displays a hexagonal crystalline wurtzitetype structure, with space group P63mc. The importance of ZnO is due to its unusual physical properties such as high conductance, chemical and thermal stability, wide and direct band gap of 3.37 eV and a high excitation binding energy of 60 MeV. Moreover, it is harmless to the environment [12-16]. Zinc oxide (ZnO) has emerged as one of the most promising materials due to its optical and electrical properties, high chemical and mechanical stability together with its abundance in nature.

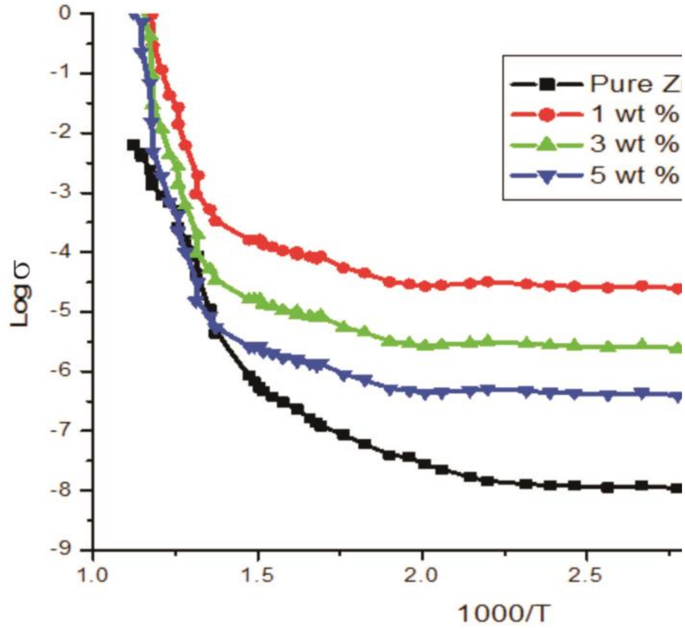
The effects of preparation conditions and doping on electrical property of ZnO-based thin films have been intensively studied because of their interesting functionalities such as transparent electric conductor, electro acoustic transducer, etc. [17, 18]. Appropriate donor doping can produce the electronic defects that increase the influence of oxygen partial pressure on the conductivity. Nanto et al. showed that a lower operating temperature may be achieved by the doping effect and a significant resistance change can be obtained in the doped ZnO rather than the undoped ZnO sensor which results in a higher sensitivity [19]. Generally, nanometer-sized materials have been widely studied in recent years, due to their good gas sensitivity caused by high surface activity. Controlled ultra fine and narrow distribution of particle size of metal oxide powders can be obtained using various techniques and the first step in keeping full control of the microstructure of the material is to control the preparation method of the starting powders. By selecting proper fabrication process, desired crystalline properties of metal oxides can be achieved

II. D.C. Electrical Conductivity Measurements

The zinc oxide was produced from one pot containing 0.50 g diethylzinc (15wt% in toluene) in approximately 15 mL dry toluene and the second pot holding approximately 20 mL dry methanol, adding the required mol.% of triethylgallium (2.0M in toluene) to the diethylzinc and toluene mixture. An aerosol mist of the precursorwas prepared, after heating the calcined powder was pressed into circular pellet forms as per the discussed procedure. [20-28] Fig. 1 shows log σ versus 1000/T plot for Ga doped ZnO (x = 0, 0.1, 0.3 and 0.5) samples. It is seen that as the temperature increases conductivity also increases, it represents the semiconducting nature of the samples. In the beginning, the rate of increase of conductivity with temperature is small for all samples and then increases after a particular temperature. The rise in conductivity is observed around 571 K, 600 K, 650 K and 602 K for pure ZnO, 1 wt % Ga doped ZnO, 3 wt % Ga doped ZnO and 5 wt % Ga doped ZnO samples respectively. The transition temperature for doped samples is observed to be shifted to the higher temperature range as compared to the undoped. The conductivity of 3 wt % Ga doped ZnO is greater than that of the others i.e. 650 K.

The activation energy is calculated from the slope of the log σ Versus 1000 / T plots in two sides of the curves for temperature regions. In low temperature region the values of activation energy are 0.0391 eV, 0.0366 eV, 0.0368 eV and 0.0367 eV and in high temperature region these are 0.4191 eV, 0.41 eV, 0.412 eV and 0.401 eV for pure ZnO, 1 wt % Ga doped ZnO, 3 wt % Ga doped ZnO and 5 wt % Ga doped ZnO samples respectively. The activation energies are varying with dopants. With slight change in it is for the sample with 3 wt % doping of Ga in ZnO is recorded.

Thus it is observed that in both the temperature regions, there is a slight change in activation energy due to the doping. But the activation energy values are found to be smaller in low temperature region as compared to the high temperature region. It supports the changing conduction mechanism of the samples with respect to temperature. The activation energy values indicate electronic conduction at lower temperatures and ionic conduction at higher temperatures. We are interested in electronic conduction of the semiconductor material for further study.



III. Conclusion

1. The physical properties which includes Electrical conductivity study of 0, 1, 3 and 5 wt. % gallium doped ZnO system are reported here. The wurtzite hexagonal structure along with the crystallite size is confirmed from JCPDS data. The nano-crystallites are having spherical nature of the particles for all the samples. Further studied and responsible system with 3 wt % doped Ga in ZnO has average crystallite size of 64 nm. It is found that the lattice parameters decreases with the increase in doping concentration which are depicted along with crystallite size.
2. As the temperature increases, conductivity increases, which supports semiconducting nature of the samples. The rise in conductivity is observed around 650 K for 3 wt % Ga doped ZnO shows higher transition temperature. Activation energy calculated has 0.0368 eV for lower and 0.412 eV for higher temperature range of 3 wt % Ga doped ZnO.

IV. REFERENCES

[1]. Seiyama T., Kato A., Fujiishi K., Nagatani M., Anal. Chem., 34(1962), 1502.

[2]. Moseley P. T., Sens Actuators B Chem., 6(1992), 149.

[3]. Seiyama T., Era F., Zairyo-Kagaku Jpn., 8(1971), 232.

[4]. Pizzini S., Butta N., Narducci D., Palladino M., J. Electrochem. Soc., 136(1989), 1945.

[5]. Wagh M. S., Jain G. H., Patil D. R., Patil S. A., Patil L. A., Sens. Actuators B, Chem. , 115(2006), 128.

[6]. Patil L.A., Patil D.R., Sens Actuators B Chem., 120 (2006), 316.

[7]. Patil D.R., Patil L.A., Sensors and Transducers, 70(2006), 661.

[8]. Wang Yan, Kong Fanhong, Zhu Baolin, Wang Shurong, Wu Shihua, Huang Weiping, Mater. Sci. Eng. B, 140(2007), 98.

[9]. Neri G., Bonavita A., Rizzo G., Galvagno S., Pinna N., Niederberger M., Capone S., Siciliano P., Sens Actuators B Chem., 122(2007), 564.

[10]. Kapse V.D., Ghosh S.A., Chaudhari G.N., Raghuwanshi F.C., Talanta, 76(2008), 610.

[11]. Hotovy I., Rehacek V., Sicilian P., Capone S., Spiess L., Thin Solid Films, 418(2002), 9.

[12]. Liu R., Vertegel A.A., Bohannan E.W., Sorenson T.A. And Switzer J.A., Chem. Mater., 13(2001), 508.

[13]. Kaur R., Singh A.V., Sehrawat K., Mehra N.C. And Mehra R.M., J. Non-Crystal. Solids, 352(2001), 2565.

[14]. Kubota J., Haga K., Kashiwaba Y., Watanabe H., Zhang B.P. And Segawa Y., Appl. Surf. Sci., 216(2003), 431.

[15]. Singh S., Thiyagarajan P., Kant K.M., Anita D., Thirupathiah S., Rama N., Tiwari B., Kottaisamy M. And Rao M.S.R., J. Phys. D: Appl. Phys., 40(2007), 6312.

[16]. Reynolds D.C., Look D.C. And Jogai B., Appl. Phys., 89(2001), 6189.

[17]. Kim K.H., Park K.C., Ma D.Y., J. Appl. Phys., 81(1997), 7764.
[18]. Jimenez-Gonzalez A.E., J. Solid State Chem.,128(1997), 176.
[19]. Nanto, H.; Minami, T.; Takata, S. J. Appl. Phys., 60(1986), 482.
[20]. Kapse V.D., Ghosh S.A., Chaudhari, G.N., Raghuwanshi F.C., Vacuum, 83(2009), 346.
[21]. Baruwati B., Kishore Kumar D., Manorama S.V., Sens Actuators B, Chem., 119(2006),676.
[22]. Kwon Y.J., Kim K.H., Lim C.S., Shim K.B., J. Ceram. Proc. Res., 3(2002), 146.
[23]. Silva R.F., Zaniquelli M.E.D., Colloid Surface. A, 198–200(2002), 551.
[24]. Li H., Wang J., Liu H., Yang C., Xu H., Li, X. Cui H., Vacuum, 77(2004), 57.
[25]. Dong L.F., Cui Z.L., Zhang Z.K., Nanostructure. Mater., 8 (7) (1997), 815.
[26]. Sze S.M., Chemical Sensors, Wiley, New York, 1995, Pp. 383.
[27]. Watson J., Sens Actuators B Chem., 5(1984), 29.
[28]. Morrison S.R., Sens Actuators B Chem., 12(1987), 425.
[29]. Korotcenkov G., Boris I., Cornet A., Rodriguez J., Cirera A., Golovanov V., Lychkovsky Yu., Karkotsky G., Sens Actuators B Chem., 120(2007), 657.

Cite this article as :

N. R. Thakare, V. R. Chinchamalatpure, "D. C. Electrical Conductivity of Ga doped ZnO", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 10 Issue 5, pp. 132-135, September-October 2023. Available at doi :
https://doi.org/10.32628/IJSRST52310526
Journal URL : https://ijsrst.com/IJSRST52310526