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Dielectric properties of pure and zinc doped CuO Nanoparticles

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Abstract : *Nano copper oxide attracts more and more people's attention and has become one of the most extensively used inorganic materials. Pure and zinc doped copper oxide nanoparticles were synthesized using microwave assisted solvothermal method. The dielectric constant is one of the basic electrical properties of solids and the measurement of it and dielectric loss as a function of frequency and temperature is of great interest both from theoretical point of view and from the applied physics. Dielectric properties of pure and zinc doped CuO Nanoparticles were analyzed and the results are discussed*
Keywords *- metal oxides,solvothermal synthesis, dielectric constat.*

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I. INTRODUCTION

The oxides of transition metals are an important class of semiconductors having applications in multiple technical fields like solar energy transformation, magnetic storage media, electronics and catalysis [1-3]. Among the oxides of transition metals, copper oxide nanoparticles are of special interest because of their efficiency as nanofluids in heat transfer application [4], secondly it is the basis of several high-Tc superconductors [5]. CuO is a semiconducting material with a narrow band gap and is used for photoconductive and photothermal applications [6]. Opposite to n-type semiconducting metal oxides, copper oxide (CuO) is a p-type semiconductor with a band gap of 1.2-1.9 eV. Its applications also include catalysis, lithium-copper oxide electrochemical cells, solar cells and gas sensors [7-9].

Copper oxide is widely used in the field of superconductors and ceramics as a kind of important inorganic materials. Dielectric constant can be measured by determining the change in the capacitance of specially designed condenser when the dielectric material is inserted between plates of that condenser. Practically the presence of a dielectric material between the plates of a condenser enhances the capacitance provides the basic experimental method for the measurement of dielectric constant. Various polarization mechanisms in solids such as atomic polarization of the lattice, orientational polarization of dipoles and space charge polarization can be understood very easily by studying the dielectric properties as a function of frequency and temperature for crystalline solids [10-11]. Dielectric properties for all the prepared samples in the present study using the conventional parallel plate capacitor method using an LCR meter (Agilent 4284 A) with various frequencies with various temperature ranging from 30-100^{o}C in a similar way followed by Mahadevan and his co-workers [12-14].

II. EXPRIMENTAL METHOD

For the preparation of pure CuO nanoparticles, Analytical reagent (AR) grade copper acetate urea, ethylene glycol (as solvent) can use as precursors. Copper acetate and urea can take as solute in the molecular ratio 1:3 and dissolve in 100 ml ethylene glycol individually. The prepared solution is keep in a domestic microwave oven. Microwave irradiation is carried out for about 20 minutes till the solvent is evaporates completely. For zinc doping, zinc acetate is used.

The nanocrystals were pelletized and used for the dielectric measurements. The flat surfaces of the cylindrical pellets were coated with good quality graphite to obtain a good conductive surface layer. The observations at various temperatures were made while cooling the sample. Air capacitance (C_a) was also measured for the thickness equal to that of the pellet. Air capacitance was measured only at room temperature as it does not change significantly with temperature variation.

III. RESULTS AND DISCUSSIONS

Dielectric constant, dielectric loss and AC electrical conductivity of the prepared pure and zinc doped CuO nanoparticles were observed in the present study are shown in figures. The dielectric parameters are observed to increase with increase in temperature for all the samples. Also doping leads to reduction in the dielectric parameters.

The dielectric constant (ε_r) is attributed to four types of polarization which are space charge, dipolar, ionic and electronic. At lower frequencies, all four types of polarizations contribute. The rapid increase in dielectric constant is mainly due to space charge and dipolar polarizations which are strongly temperature dependent. The (σ_{ac}) values observed in the present study are very small which increases with increasing temperature. Thus the space charge contribution plays an important role in the charge transport process and polarizability in the present study.

All the three parameters increase with increase in temperature for the entire prepared sample considered for this study. From the dielectric studies it is also seen that the dielectric constant increases with decreasing frequency and increases in temperature. Nano crystalline materials create enormous number of interfaces and the large number of defects present at these interfaces can cause a change of positive and negative space charge distribution. When an electric field is applied, these space charges move and trapped by these defects, resulting in the formation of dipole moments. This is called space charge polarization.

In the fourth stage polarization is only due to the electronic and hence the dielectric constant value goes low around 1MHz. Dielectric loss figures show the variation of dielectric loss with frequency at various temperatures, it is observed that the tan δ values are decreased with increase in frequency and also tan δ values are increased with increase in temperatures. It is evident from the figures that tan δ also increases with increase of temperature and has a decreasing trend at elevated frequencies. This can be attributed to the fact that the electric relaxation is a thermally activated process in the materials under study. The decrease in loss factor may be attributed to the space charge polarization which arises due to the accumulation of charge carriers at grain boundaries under the application of external electric field.

From the AC conductivity graph, it is seen that as frequency increases the conductivity remains more or less constant at low frequencies, but at higher frequencies, as the frequency increases the conductivity also increases. The variations are similar for other temperatures, but the values are shifted upwards as the temperature rises.

This increase in dielectric constant as a result of increase in temperature can be explained on the basis of the phenomenon that as the temperature increases, the dipoles relatively become free and they respond to the applied electric field. Consequently the polarization increased and hence dielectric constant also increases with the increase in temperature [15,16].

IV. FIGURES AND TABLES

T Dielectric constant, dielectric loss and AC electrical conductivity of the prepared pure and zinc doped CuO nanoparticles were observed in the present study are shown in Fig.

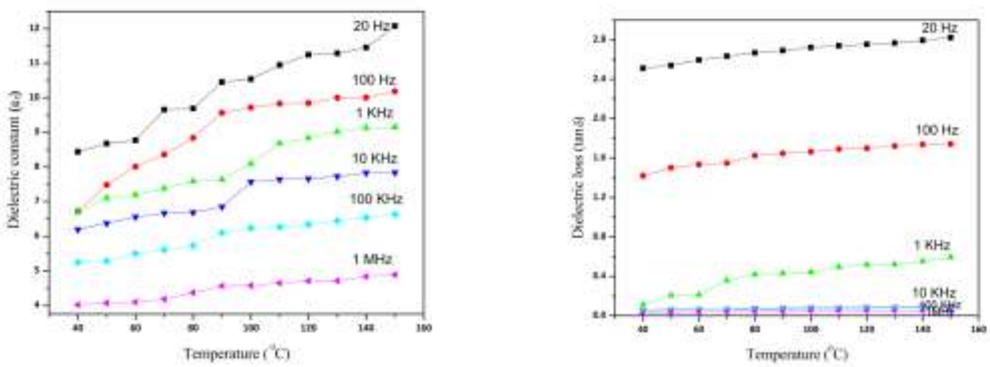

Fig: Dielectric constant and Dielectric loss plot for pure CuO

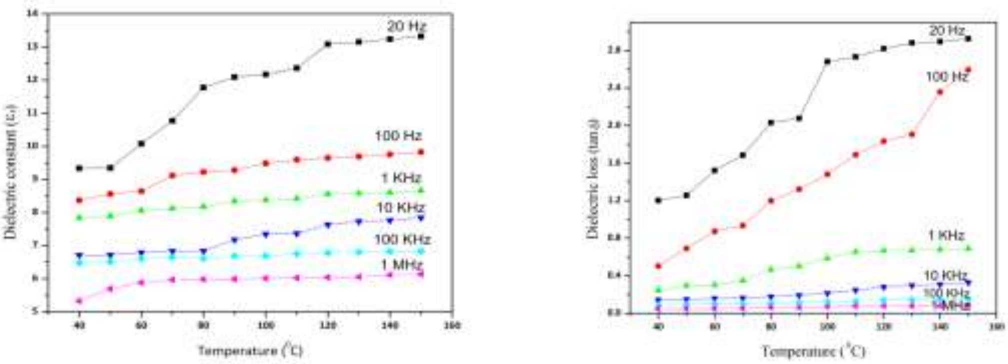

Fig: Dielectric constant and Dielectric loss plot for Zn-doped CuO (2 wt%)

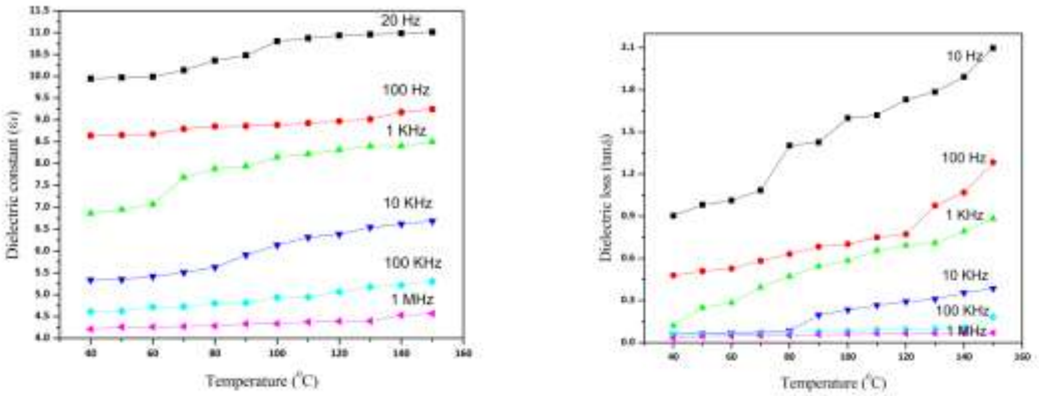

Fig: Dielectric constant and Dielectric loss plot for Zn-doped CuO (5 wt%)

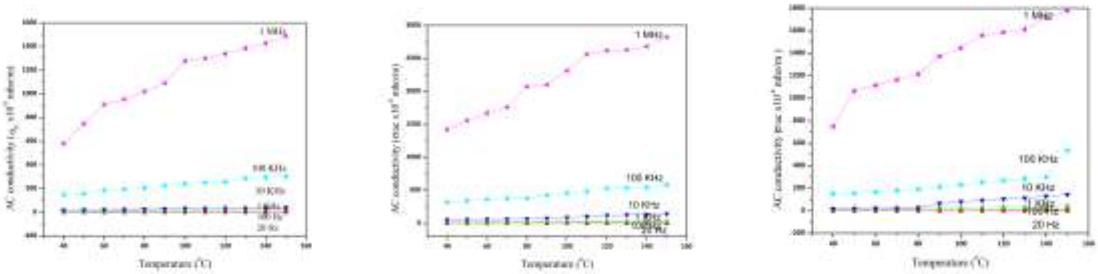

Fig: AC conductivity plot for pure CuO and Zn-doped CuO (2 wt%) &(5 wt%)

V. Conclusion

Dielectric constant, dielectric loss, and the AC electrical conductivity presented in the figures show that all the three parameters increase with increase in temperature for the entire prepared sample considered for this study. This increase in dielectric constant as a result of increase in temperature can be explained on the basis of the phenomenon that as the temperature increases, the dipoles relatively become free and they respond to the applied electric field. AC conductivity increases with the increase in temperature and frequency, indicating the mobility of charge carriers responsible for hopping.

REFERENCES

[1]. E.P. Wolhfarth, Ferromagnetic Materials, Vol. II, North-Holland, Amsterdam, New York, Oxford, Tokyo, p. 405 (1980).
[2]. J.C. Mallinson, “the Foundations of Magnetic Recording”, Academic Press, Berkeley, CA, Chapter 3 (1987).
[3]. P.O. Larsson, A. Andersson, R.L. Wallengerg and B. Svensson (1996) J. Catal. **163**, 279.
[4]. M. Chang, H. Liu and C.Y. Tai (2011) Powder Technology **207**, 378–386.
[5]. H. Wang, J. Xu, J. Zhu and H. Chen (2002) Journal of Crystal Growth **244**, 88–94.
[6]. A.E. Rakhshni (1986) Solid State Electron. **29**, 7.
[7]. J. Zhang, J. Liu, Q. Peng, X. Wang and Y. Li (2006) Chem. Mater. **18**, 867–871.
[8]. A. Cruccolini, R. Narducci and R. Palombari (2004) Sens. Actuators B **98**, 227–232.
[9]. Y.S. Kim, I.S. Hwang, S.J. Kim, C.Y. Lee and J.H. Lee (2008) Sens. Actuators B **135**, 298-303.
[10]. T.H. Freeda and C.K. Mahadevan (2000) Bull.Mater.Sci. **23**, 335.
[11]. K.V. Rao and A.A. Smakula (1965) J. Apply Phys. **36**, 2031.
[12]. V.N. Praveen and C.K. Mahadevan (2005) Indian J. Phys. **79**, 639.
[13]. S. Perumal and C.K. Mahadevan (2005) Physica B **367**, 172.
[14]. G. Selvarajan and C.K. Mahadevan (2006) J. Mater. Sci. **41**, 8218
[15]. H.M. Chenari, M.M. Golzan, H. Sedghi, A. Hassanzadeh and M. Talebian (2011) Current Appl. Phys. **11**, 1071-1076.
[16]. F. Bakhtiari and E. Darezereshki (2011) Mater. Lett. **65**, 171.

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