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STUDY OF ELECTRICAL CONDUCTIVITY AND CONDUCTION MECHANISM OF $CuNiTiO_4$

R.H. Amnerkar, R.N. Ghodpage, N.D. Narkhede and S.H. Dhawankar

Institute of Sciences College, Nagpur - 18 (India)
Sindhu Mahavidyalaya, Nagpur (India)

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ABSTRACT

A compound $CuNiTiO_4$ is prepared by Solid diffusion method in the laboratory using standard chemical crystallographic of $CuNiTiO_4$ is done using XRD. The Electrical properties are studied under which the variation of electrical conductivity with respect to temperature is obtained and type of charge carriers is determine electrical resistivity of the sample can be measured with dc or ac method. In the present work dc method is used, using LCR meter for the resistivity measurements.

Keywords: Electrical conductivity, $CuNiTiO_4$ and LCR meter.

INTRODUCTION

A group of oxides with chemical formula XY_2O_4 which has crystal structure of magnesium aluminate ($MgAl_2O_4$) or mineral hausmannite (Mn_3O_4) is known as 'spinel'. The crystal structure of $MgAl_2O_4$ has been determined completely by Bragg and Nishikowa independently in the year 1915, which was found to be cubic crystal. It is interesting to note that all the compounds with chemical formula X_2O_4 do not necessarily have the spinel structure. The essential condition for the formation of oxidic spinels is that the cationic radii should be between 0.45 Å to 0.95 Å.

In spinel structure it is seen that there are two types of interstices, available, one formed by four anions of the vertices of tetrahedran and other by six anions of the vertices of an octahedran. These interstices are called the tetrahedral (A) site and octahedral (B) site respectively. The positions of the anions are variable and are specified by the symmetry of the structure.

Site distribution of cations in the spinels plays an important role in the understanding of electrical and magnetic properties. Much theoretical as well as experimental work has been done for finding out the distribution. It was first believed in an oxidic spinels the metal ions would tend to occupy the same sites as in the oxides. Thus the metal oxides having zinc blend and rock salt structure would tend to occupy Tetrahedral and a Octahedral sites respectively. However belief was found to have limited applicability.

Several workers have classified the cations according to their distribution in the spinels. Verway and Heilmann have classified the cations assuming a purely ionic model. According to them the presence of the ions for A and B sites is as follows

a) Zn^{+2}, Cd^{+2}, Ga^{+3}, In^{+3}, Ge^{+4} prefer A sites
b) Ni^{+2}, Cr^{+3}, Ti^{+4},Sn^{+4}, prefer B sites
c) Mg^{+2}, Fe^{+2},Co^{+3}, Mn^{+2}, Fe^{+3} are indifferent ions.

In the present work we have prepared spinel containing copper, zinc and titanium. It is found that Ni^{+2} has large A site preference energy while Ti^{+4} have B site preference energy and Cu^{+2} distribution also have A site. Therefore the study of site distribution is highly interesting. Here the electrical conductivity of the spinel is studied.

Cationic radii of the elements used in the present works

Element	Ionic radii
Cu^{+2}	0.72Å
Ni^{+2}	0.74 Å
Ti^{+4}	0.68 Å

EXPERIMENTAL

Preparation of Pellets

For making pellets for electric conductivity measurement, the sample was finally powdered in an agate mortar, and then mixed with 5% polyvinyl acetate solution in A.R. grade, which serves as binder. It was found that about 2 cc of the binder per gram of the sample was required to give well modulated pellets suitable size for studying it. The

plastic mass to obtained by mixing sample with binder was pressed in hydrauline press of 0.9 cm diameter die under the pressure of 5 - 8 tones per square meter.

The pellets thus prepared was placed in ceramic boat and slowly heated in air upto 400°C when the binder either evaporated or burn off. The pellet was maintained at this temperature for one and half hour then temperature of furnace was rised 800°C to 900°C. The pellet was maintained at sintering temperature for 3 - 4½ hours and finally quenched at room temperature in air, which form the suitable pellets for study of electrical conductivity.

Measurement of Electrical conductivity

The resistivity of these compounds was measured by using specially fabricated sample holder. A typical sample holder consist of two stainless steel electrodes, one of which is fixed to asbestos plate by means of huts made up of brass. The other electrode is also fixed to asbestos plate but it is spring load, which pressed hoard against the surface of the pellets. The resistivity of compound measured using sample holder, which ensures the smooth contact of electrodes with the surface of pellets. For this the diameter and thickness of pellets was accurately measured with the help of screw gauge. The pellets then coated with silver paste. The coated pellets were tested with multimeter so as to ensure the continuity on both the surface independently. It was ensured that the two surfaces had no inter-continuity between them. The measurement of the temperature was connected to simple holder.

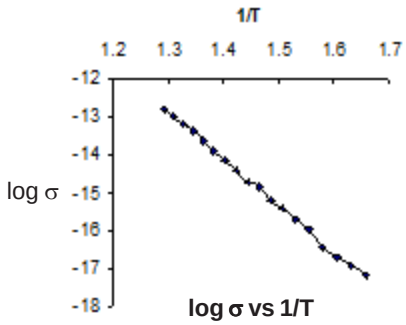
The ends of the holder are connected to LCR meter. The holder is kept free from contact of furnace coil. The furnace heating arrangement is done with the help of variac. The temperature of furnace was increased to about 783K and then dc resistance was measured for every 10K few in temperature till it falls to 623K. The conductivity is calculated as s = t/RA.

RESULTS AND DISCUSSION

The crystallographic data of the compound $CuNiTiO_4$ is studied in this project work. The X-ray diffraction study shows that the compound crystallized in a single phase.

The crystallographic data for the spinel is given in the table. the table of data include h,k,l value their corresponding observed and calculated interplaner spacing and relative intensities. By indexing the difractogram the values of lattice parameter are found to be a = 8.45 Å. From the X-ray diffraction pattern obtained the spinel structure is confirmed to be Fd_3m. hence face centered cubic structure of $CuNiTiO_4$ is confirmed.

Density is calculated by r = m/n × z/v = 5.3201 gm/cc and conductivity is given by $\sigma = 1/\rho$. Electrical conductivity results show that the value of conductivity rise with temperature, for activation energy 0.9048 ev obey the Wilson's law indicating semi conducting nature of the compound.



log σ vs 1/T

Logarithm of conductivity log s vs 1/T k^{-1} and in linear range of the graph the activation energy of electrical conductance was determined from the slope of straight line. There are several methods to used for the interoperation of conduction mechanism. These include hot probe method, we used hot probe method to determine the type charge carriers and compound under study is found to be p – type charge carrier.

REFERENCES

1. Bragg, W.H. *Phil Mag* **30,** 305-315 (1915)
2. Nishikawa, S. Poc. Tokyo *Math., Phy. Joc* 8199-8209.
3. Verwey, E.J.W. & Heilman, P.W. *J. Chem. Phy,* **15,** 174 (1947)
4. Mc. Gurire T.R. and Greenwald S.W. *Solid state Physics and Telecom* 350 (1960)
5. Henry N.F.M. and Londsdalt K, *International table for X-ray Crystallography,* **2** (1951)
6. John, H.A. & Jeller, E. *Proc. Roy. Doc A* **161** (1955)
7. Solid State Physics by A.J. Dekker.
8. Kittel, Introduction to Solid State Physics.
9. Debye P & Scherrer P, *Physics Z.,* **17,** 277 (1916) & **18**, 219 (1917)