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Electrical Properties of K_2 CuO_2

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Abstract

Potassium copper oxide K_2 CuO_2 compound was prepared under high pressures and temperatures. Pure AR grade K_2O and CuO compounds were taken in stochiometric ratio. This paper summarizes electrical properties of the sample. The activation energies (Ea) of the prepared sample pellet at 400K & 700K are calculated as 0.1ev and 0.6ev respectively. The carrier concentration of charge carriers (σ) is estimated through TEP as 10^{15} to10^{16}cm^{-3}. It is recorded that the Seebeck's coefficient is constant upto 150μv/k and increases rapidly with temperature afterwards. Conductivity 'σ' and Dielectric constant '$\in$' are estimated 6.58X10^3 mhos cm^{-1} and 600 respectively. This type of materials are used as sensors, varistors, electro-graphy, Medical materials etc.

Keywords: TEP = Thermal electric power, Ea = Activation energy, $\in$ = Dielectric constant, and σ = Conductivity.

Introduction

Ceramics materials are having a wide range of practical applications in modern technology. These are stable at high temperatures and low cost manufacturing have attracted much attention. A good ceramic capacitor should have a large dielectric constant 'ε. This is however not a sufficient condition, it should also require a low dielectric loss (a low dissipation factor tan δ = E/E which is related to loss of stored electricity) Some pervoskite oxides (e.g.$BaTiO_3$ and Pb(Mg1/3 Nb2/3)O_3 are widely used as capacitor materials and exhibits a high ε (1000-20000) with a low tanδ (0.01-0.2) investigated in (1) ceramics samples such as $CaCu_3Ti_4O_{12}$ have a very large ε of 10000, which is constant over a wide range from 100to 400K below 1MHz discovered and examined (2,3). These investigations attracted many researchers interest from both technological and scientific (4,5,6,7) points of view. The body centered cubic (bcc) pervoskite related materials $CaCu_3Ti_4O_{12}$ shown high value for the state dielectric constant 'ε_o' nearly 10^4 measured in ceramics in the radio frequency region (1,2,3) and was found to be practically constant in the 100-600K region. Both properties are important for device implementations (8,9).

Potassium copper oxide K_2CuO_2 compound was prepared under high pressure and temperature. Pure AR grade K_2O and CuO compounds were taken in Stochiometric ratio. The present investigation summarizes the electrical properties of the sample. The sample activation energies (Ea) are calculated between temperature 400K and 700K. The ceramic calcinations also estimated. The See beck's coefficient also taken under consideration and recorded and found constant up to 150μv/k. The dielectric constant 'ε'recorded 600 the ceramics are studied (10-15). The conductivity also recorded and determined $6.58x10^{-3}$ mhos.cm-1

Experimental details

Sample preparation and measurements

Sample for measuring electrical conductivity and dielectric constants were prepared. Stochiometric Potassium copper oxide was synthesized in air by the high temperature solid state reaction. Raw materials of reagent grade K_2O and CuO were weighted on a electronic single pan balance (Afcost model) purity of powders were higher than 99%. The reagent grade materials were mixed with agate mortar and pestle for over two hours, dried and calcinated.

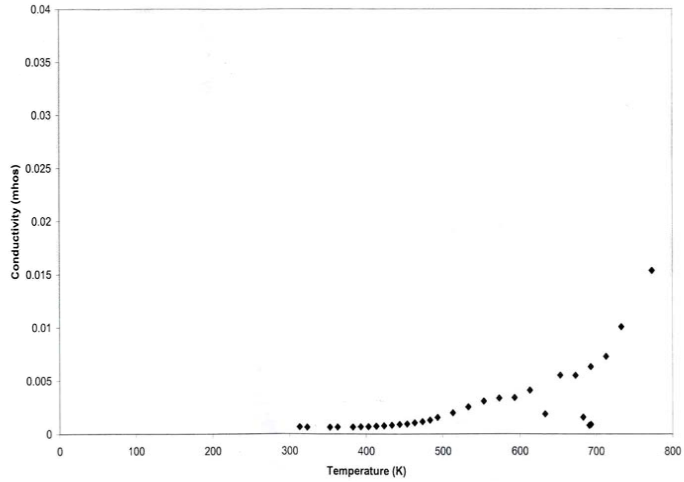
Alumina crucible containing proper mixtures in various compositions was in an electrical muffle furnace which can be heated up to 800 0c made from a mullet tube with kanthal heating elements. The mixture was heated gradually up to 700^oC at which temperature it was allowed several hours for homogenization of mixture. The formation of the K_2CuO_2 was confirmed by powder X-ray diffraction method.

The resulted powders were made into pellet by using hydraulic press type w-11,sl. #378(kimaya engineers, thane Bombay)and applied pressure 6-8 tones finally sintered at 850^oC for eight hours. The suitable firing temperature can be determined by studying the shrinkage and apparent density of the products for different firing schedules. The sintering increases mechanical strength of the pellet. These pellets were then annealed at 700^oC for about four hours under vacuum (10^{-2} torr) to remove the strain developed during mechanical stress. The parallel faces of the pellet were polished flat using silicon carbide (#200,#400,#600)papers.

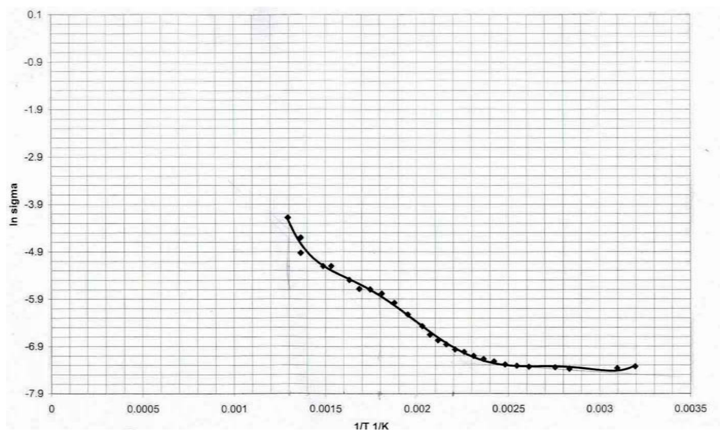
Results and discussions

Electrical conductivity

Using two terminal method d.c. resistivity measured with Keithley DMM-2700 for the oxide specimens have been performed keeping 10 volts across two electrodes of dielectric cell. By knowing the current passing through the circuit and the voltage across the sample, the resistivity of the sample can be calculated using the equation, $\sigma = RA/ t$ where 'R ' is the resistance, A is the cross section area of the sample and 't ' is the thickness of the sample.



3.1.2 1/T v/s In sigma K_2CuO_2

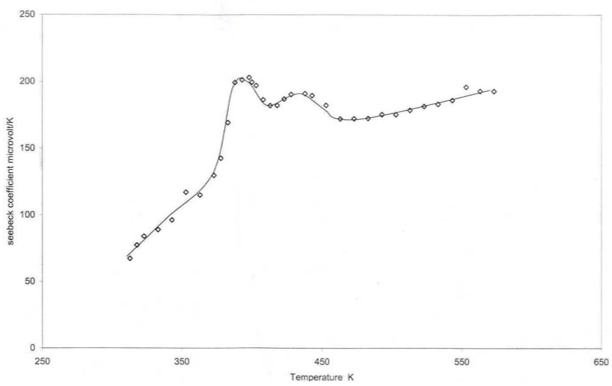


3.1.1 Conductivity Vs temperature of K_2CuO_2

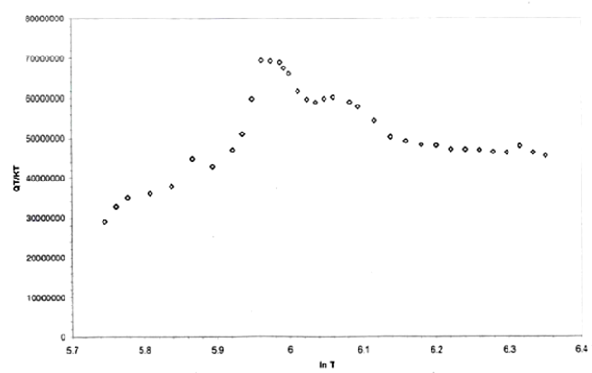
Shows the temperature variation of electrical conductivity of the sample K_2CuO_2.The electrical conductivity was drawn as a function of temperature. It was observed from that graph that electrical conductivity increases with the increase of temperature. It indicates the behavior of a semiconductor. It may be due to excess of metal like copper was available in the sample. At high temperature increase is exponential. This is a general behavior of a polycrystalline ceramic material. At room temperature the conductivity of the pellet is about twenty two orders of magnitude small than the conductivity of typical metallic conductors. The high temperature mechanism is attributed to thermal excitation of the charge carriers across the potential barrier at grain boundaries. This large difference in 'σ' is due to the wide band gap in insulators (15).The conductivity values at different temperature were presented in the table.3.1.3.

Table 3.1.3: Electrical, thermoelectric and dielectric data of K_2CuO_2

Sample		$KCuO_2$
Resistance		400
Conductivity σ ($mho.cm^{-1}$)		6.58×10^{-3}
Seebeck coefficient α ($\mu V/K$)		80
Dielectric constant (ε)		600
Activation energy (E_a) eV	At 400K	0.1
	At 700K	0.6



3.2.1 temperature variation of seeback coefficient of K_2CuO_2

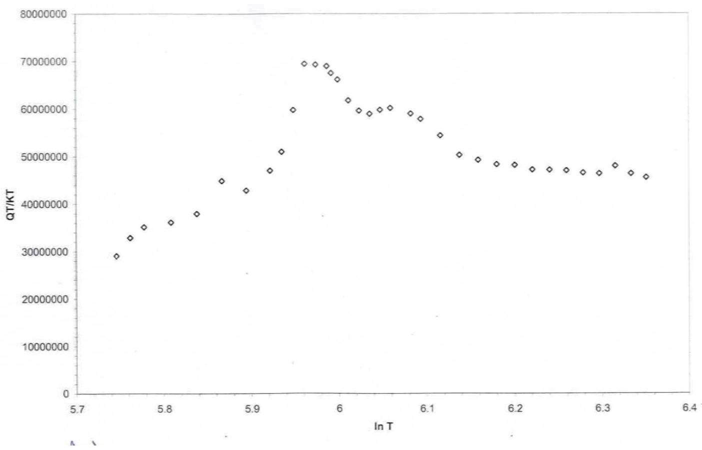


3.2.2 QT/KT VsInT of K_2CuO_2

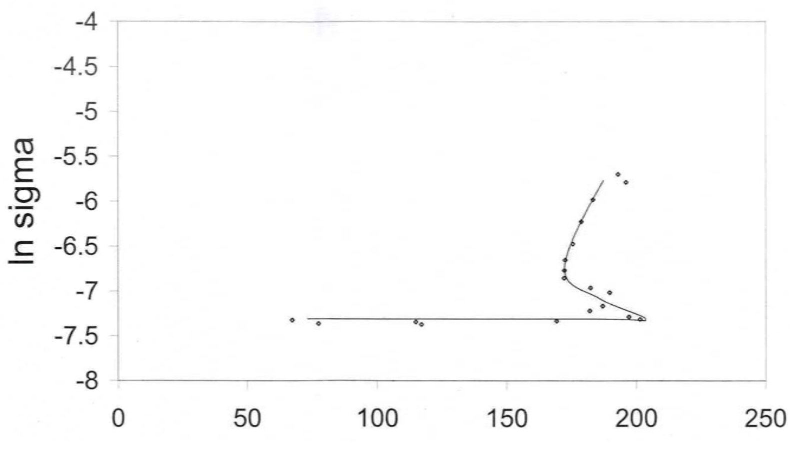
Figure 3.1.2 depicts the temperature variation of logarithmic of electrical conductivity'σ' was drawn as function of reciprocal of the temperature. The activation energies (Ea) were determined by the relation,' $\sigma = \sigma_o \exp(Ea/KT)$ where

Ea is the activation energy, 'T is the absolute temperature and 'K' is the Boltzmann constant. It was observed that the Ea remains constant up to 400K and increase further increase of temperature. This indicates charge carriers are thermally generated and they have mobility at low temperature.

Thermo electric power (TEP); Figure 3.2.1. depicts the temperature variation of thermo electric power of the sample K_2cuO_2, Seeback coefficient was drawn as function of temperature.It was observed that TEP increases with increase of temperature. The TEP has positive sign and hence the majority charge carriers are holes. From this phenomena we may conclude the sample was p-type semiconductor. T was also observed that around 400 to 500K some abnormal behaviour but similar nature was not observed in the conductivity and dielectric studies. We may conclude that it may have some low temperature phase transformation at around 500K.The plot 3.2.2 which was drawn logarithmic temperature verses charge carrier concentration 'n' of the sample. charge carrier concentration was also estimated from TEP found 10^{15} to 10^{16} cm^{-3}.



3.2.2 QT/KT Vs In T of K_2CuO_2

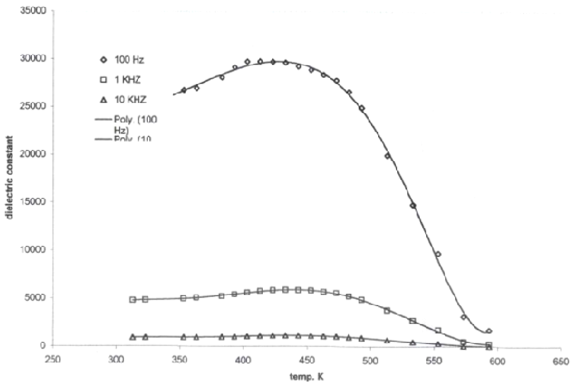


3.2.3 see beck coefficient micro V/K

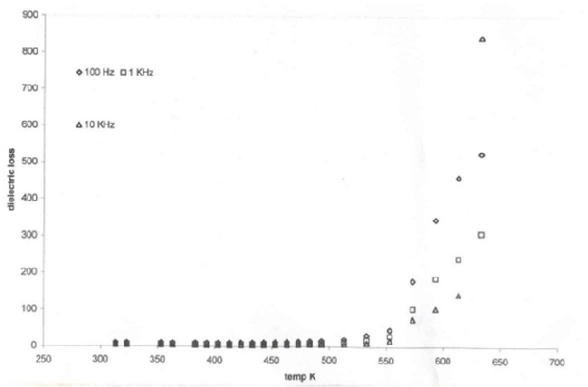
The plot 3.2.3 was drawn between Seebeck coefficient on x-axis and log of sigma on y-axis. It was observed that logarithm of electrical conductivity 'σ' increases with the increase of Seeback coefficient. It was also observed that the conductivity remains constant upto Seebacks coefficient 150μv/k and then increases rapidly.

Dielectric roperties

The dielectric property can be calculated by using the relation, $\varepsilon = cd / \varepsilon_0 A$ where εo is free space permitivity, 'A' is the cross section area of the specimen and 'd' is the thickness of the sample. The capacitance of the sample was measured using LCR data bridge model #6421, Forbes Timely Co.ltd for a fixed frequency of 100 Hz, 1KHz and 10KHz. For the measurment of capacitance with the variation of frequency and temperature the dielectric cell kept in furnace, Indo-therm, Chennai. The sample was placed in both the surfaces silver pestie (Fujikura-kasei DTITED-500) was painted.



3.3.2 temperature dependence of dielectric constsant of K_2CuO_2



3.2.3 temperature dependence of dielectric loss of K_2CuO_2

Study of dielectric constant as a function of frequency (f) and temperature can be explain various polarization mechanisms in solids.

There is a distortion polarization and time dependent polarization comprises two terms,

$$P(t)= po\leftarrow p_1(t) \text{ with } p(t)\rightarrow p\,\alpha \text{ for } t\rightarrow \alpha$$

Where po = XoE, p_1 (t) $\rightarrow$ p_1 α = X1 E. from this we can get $dp_1 / dt = p_1 \alpha$ - po - p_1 / T = p_1 _ p_1 / T where T represent the time constant for an electric current and aeroscopic relaxation time for relaxations phenomena.

The frequency and wave velocity dependent dielectric property is one of the most response characteristics of the ceramic materials The variation of dielectric constant with frequency and temperature was shown in figure 3.3.2.It is observed that the dielectric constant decreases with increase of frequency and temperature. similar nature was observed in many ceramic materials (11-14).The figure 3.3.3. depicts the dielectric loss verses temperature and frequency of pellet. The dielectric loss increases with increase of temperature and decreases with frequency. It may be due to decrease of defect density and increase of its packing density of pellet.

Conclusions

The prepared sample electrical properties are thoroughly studied The activation energies of the sample were recorded for different temperatures at 400k and 700Kare calculated as 0.1ev and 0.6ev respectively. The carrier concentration ‘ n’ is estimated as 10^{15} to $10^{16}cm^{-3}$.The See beck coefficient is constant up to 150 μv/k and increases with temperature. The electrical conductivity ‘σ’ is also estimated as 6.58 x 10^3 mhos/cm. The dielectric constant is determined as 600. The properties of dielectrics are studied widely in(2)

References

[1] W. Kobayashi and I.Terasaki, Waseda University, Tokeyo, 169-8555 Japan March 19th, 2006.

[2] M.A. Subramanian, Dli,N,Duan,B.A Reisner and AW Sleight, J.Solid state chem. 151-323 (2000).

[3] A.P.Ramirez, M.A Subramanian, M.Gardal, G.Blumberg, D.Li T.Vopgt and S.M Shapare, Solid state Commum 115,217 (2000).

[4] C.C Homes, T.Vogt, SM Shapiro, S.Wakimoto and A.P Ramirez, Science 293,673 (2001).

[5] A.Koitzbch, G. Blumberg, A. Gozar, B.Dennis.A.P Ramirez.S Trebstand S.Wakimto, phys.Rev B65, 0502406 (2002)

[6] L.HR JB Neaton, M.H Cohen D.Vandebild and C.C Homes, phys Rev B65, 214112 (2002).

[7] W.Kobayashi and I. Tyerasaki phyca B329-333, 771 (2003)

[8] R.Singh and R.K Ulrich, the Electrochemical Society interference 8,26 (1999)

[9] B.G Kim, S.M Cho, T-Y.Kim and H.M Jang phys Rev Lett 89,3404 (2001)

[10] Y.Park and H.G Kim ceramic int 23,329 (1997).
[11] R.D Shannon, Journal applied physics 73, (1993) 348
[12] W.Wersing in High Frequency cerimic dielctrics and their applications for Microwave components, Electronic ceramics edited by BCH steele (Eleseview, Londan 1991)
[13] Eric cockayne, John.W Journal of applied physic 90 (2001) 1459
[14] I.R. Reistrick, In and review of Metrical Science Vol 16 (1986) 343
[15] Rolf Hummel Electronic properties of Materials cirose publicd (1994) 155-174.