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Electrical Conductivity of High Temperature Superconductors

Aanchal Saini[1], Shubham Kaushik[2]
Krishna College of Science and IT, Bijnor

ABSTRACT: In this short review, we will attempt to outline the main points of superconductivity including electrical conductivity of HTS. After a general overview of this field we analyses the theoretical and experimental curve of of YBCO (first specimen considered in this work) and conclude it.

Keywords—Superconductivity, HTS, electrical conductivity, YBCO.

INTRODUCTION

Superconductivity is an electrical resistance of exactly zero which occurs in certain materials below a characteristictemperature. It was discovered by Heike Kamerlingh Ones (Father of Super conductivity).

- In his experiments on the properties of metals in general and on the electrical conductivity (thereby resistivity) of Mercury (Hg).
- He observed that, when pure mercury is cooled, its resistivity vanished abruptly at 4.2 K.

Above this temperature, the resistivity is immensurable, while below this temperature the resistivity is very small that it is essentially zero. (ρ is in the order of 10^{-5}ohm cm). i.e., at 4.2 K, Hg is converted into a superconductor.

Also, with the discovery of Meissner effect and understanding the superconducting state of a thermodynamic phase. In 1935, Meissner found that if a superconductor is cooled in a magnetic field down to transition temperature, the lines of induction B is pushed out.

Ginsburg-landau is that is considerably easier to work with BCS theory. It is successfully explaining the microscopic theory of superconductors.

Abrikosov showed that Ginzburg theory predicts the division of superconductor into two categories now referred as type I & type II. In 1950maxwell and remolds found critical temperature, this important discovery pointed to the electron phonon interaction as microscopic mechanism responsible for superconductivity.

The complete microscopic theory of superconductivity was finally proposed in 1957 by Bardeen and cooper.In 1957 John Bardeen, Leon Cooper, and John Robert Schrieffer explained why superconductivity loses all resistance, known as the BCS theory. For their findings they shared the Nobel Prize in physics in 1972.

The BCS theory states that single electrons do not carry an electric current, but paired electrons do. These pairs are called Cooper pairs.

In 1986, Bednorz and muller discovered superconductivity. In lanthanum-basedcurate material, which had a transition temperature 35K first of HTS.it was found that replacing the lanthanum with yttrium i.e. making YBCO raised critical temperature to 90K.

High Temperature Superconductors:

Since Heike Kamerlingh-Onnes discovered superconductivity, people have been creating superconductors with higher critical temperatures. If there were room temperature superconductors, we could replace the conductors in our homes and cities with superconductors, thus saving billions of dollars.

ELECTRICAL CONDUCTIVITY OF HIGH TEMPERATURE SUPERCONDUCTORS

- The electrical conductivity of a material is one of the most important non-equilibrium property which probes that how a system relaxes to its equilibrium distribution. Measurements of the transport properties (electrical conductivity etc.)
- For example, conventional electronic transports strongly depend on the charge mobility, band structure and scattering processes. Hence, rather simple electrical measurement can teach essential characteristics of a solid.

Theories of electrical conductivity

1-Lorentz- Drude Theory

2- Somerfield's Theory

YBCO:

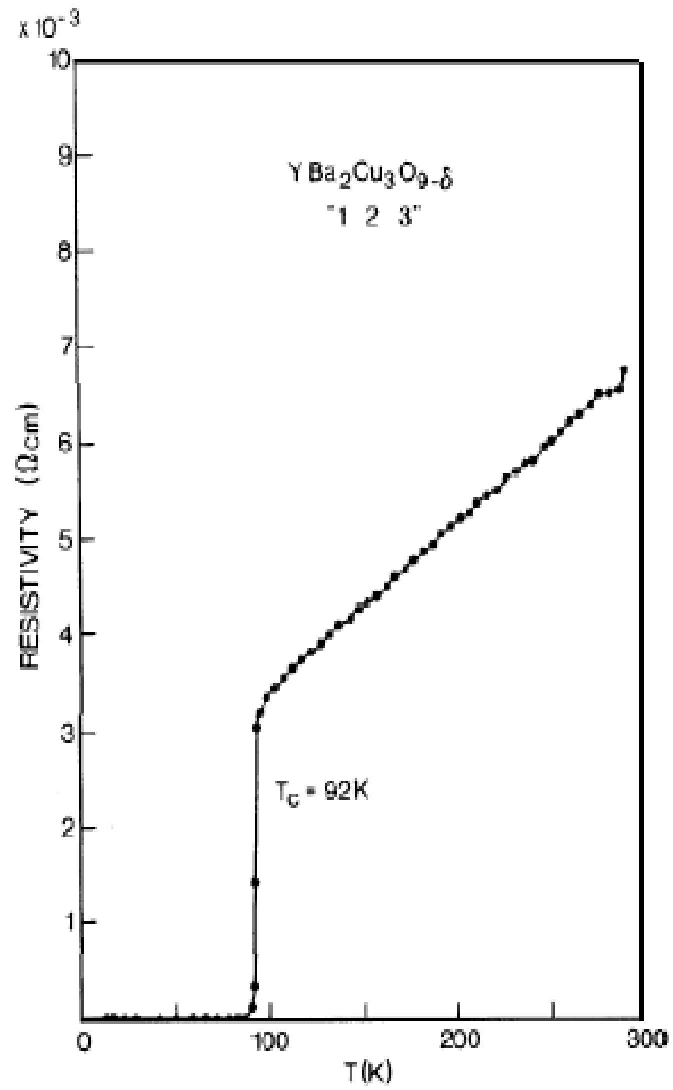
First specimen considered in this work is $YBa_2Cu_3O_{7-\delta}$ (1-2-3 structure) the first material in which superconductivity observed above the boiling point of liquid nitrogen (77 K).Itisone of the easiest curates to synthesize in the laboratory which is deficient in oxygen;

δ is a measure of deficiency in the sample. The variation in δ not only changes the crystal structure but modify the value of physical constants

It is clear that $YBa_2Cu_3O_{7-\delta}$ has very complicated electronic structure. The structure is orthorhombic with lattice constants $a \neq b$ in the superconducting region with specific values of $T_c = 92$ and $\Theta = 410$ and tetragonal with $a = b$ for $\delta > 0.5$ where it is no longer superconductor. The dimension of the unit cell, 3.855 Ǻ in the c- and a- or b-axis directions respectively. It contains a quasi-one dimensional (1D) CuO chain layer, two curates CuO_2 planes, two BaO planes.

NOW here we have taken a theortical curve of YBCO plotted between resistivity and temperature and also taken curve point through this plot and then plot an experimental curve through this data.

THEORTICAL CURVE OF YBCO:



Resistivity of YBa2Cu3O7 simple as a function at temperature.

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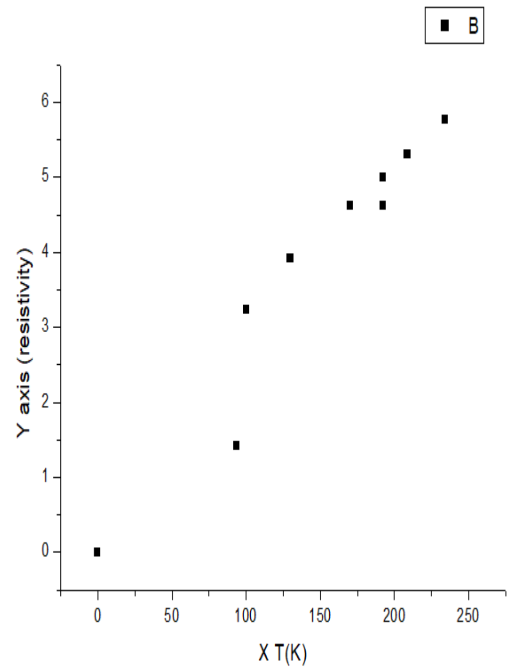
Table for curve point of YBCO

POINTS	X Temperature	Y Resistivity
1	0.000	0.000
2	93.775	1.424
3	99.984	3.229
4	129.790	3.924
5	169.992	4.618
6	192.992	4.618
7	192.326	5.000
8	208.709	5.312
9	234.023	5.764
10	278.696	6.562

EXPERIMENTAL CURVE FOR YBCO:



CONCLUSION:

The basic facts about Superconductivity are:

1. Resistivity goes to zero below the critical temperature Tc, different materials show superconductivity. Superconductors expel flux (the Meissner effect) and act as perfect diamagnet.
2. Electrical conductivity model gives σ as $\sigma = 1/\rho$ therefore it is simple to evaluate the value of the ρ if the value HTS resistivity are available.
3. That we have analyses the conductivity curve of YBCO. It is very clear that from the graph that conductivity above transition temperature is like of an

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insulator below transition temperature conductivity increase very sharply and order of parameter is of 92K. As we move down toward absolute zero even than conductivity increases reaching higher value.

This reflects that resistivity is decreasing all the time. This explains the validity of theoretical model and proves the suitability of this model to apply or other Samples to.

REFERENCES

- P. F. Dahl, Superconductivity, Its Historical Roots and development from Mercury to Ceramic Oxides (AIP, New York, 1992).
- H. KamerlinghOnnes, Comm. Phys. Lab. Univ. Leiden **122** B (1911) 1240.
- W. Meissner and R. Ochsenfeld, Naturwiss **21**, (1933) 787.
- C. J. Garter, Nature **132**, (1933) 931.
- H. Thomas, Earlier and Recent Aspect of Superconductivity, eds. J.G. Bednorz and K.A. Muller (Springer-Verlag, New York, 1990) 31.
- F. London, Superfluid's: Microscopic Theory of Superconductivity Vol. **I**, (John- Wiley & Sons, New York, 1950).
- L. Hoddeson, E. Braun, J. Teichmann and S. Weart, Out of Crystal Maze (Oxford Univ. Press, New York, 1992).
- E. Maxwell, Phys. Rev. **78**, (1950) 477.
- C. A. Reynolds, B. Serin, W.H. Wright, and L. B. Nesbitt, Phys. Rev. **78**, (1950) 487.
- H. Fröhlich , Phys. Rev. **79**, (1950) 845.
- L. N. Cooper, Phys. Rev. **104**, (1956) 1189.
- J. Bardeen, L. N. Cooper and J. R. Schrieffer, Phys. Rev. **108**, (1957) 1175.
- V. L. Ginzburg and L. D. Landau, Sov. Phys. JETP **20**, (1950) 1064.
- L. D. Landau, Z. Physik **64**, (1930) 629.
- L. P. Gor'kov, Sov. Phys. JETP **7**, (1959) 1364.
- Abrikosov, Sov. Phys. JETP **5**,(1957) 1174.
- P. W. Anderson, Phys. Rev. **112**, (1958) 1900.
- N. N. Bogoliubov, N. V. Tolmachev, and D. V. Shirkov, A New Method in the Theory of Superconductivity (Consultants Bureau, Inc., New York, 1959) 66.
- J. Valatin, Nuovo Cimento **7**, (1958) 843.
- P. G. de Gennes, Superconductivity of Metals and Alloys (W.A. Benjamin, INC., New York, 1966).
- L. P. Gor'kov, Sov. Phys. JETP **7**, (1958) 505.

- G. M. Eliashberg, Sov. Phys. JETP. **38**, (1960) 966.
- Y. Nambu, Phys. Rev. **117**, (1960) 648.
- P. Morel and P. W. Anderson, Phys. Rev. **125**, (1962) 1263.
- J. R. Schrieffer, D. J. Scalapino and J. W. Wilkins, Phys. Rev. Lett. **10**, (1963) 336.