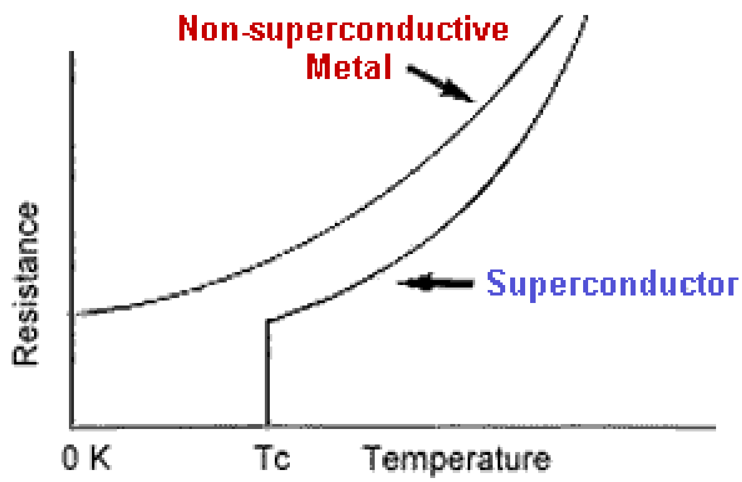
Superconductivity

Introduction

When cooled to sufficiently low temperatures, a large number of metals and alloys can conduct electric current without resistance. Obviously, these specific materials undergo a phase transition to a new super –conducting state characterized by the complete loss of d.c. resistance below a well defined critical temperature, T_c. Thus zero resistivity ($\rho = 0$), i.e. infinite conductivity is observed in a superconductor at all temperatures below a critical temperature ($\rho = 0$ for all $T < T_c$). However, if we pass a current higher than the critical =current density J_c, superconductivity disappears. This limits the maximum current that the material can sustain and is an important problem for applications of superconducting material. For elements, the transition temperature, T_c, lies generally below 10 K. Figure.1 shows resistance versus temperature for a low-temperature superconductor. At the transition temperature T_c the resistance drops abruptly to an immeasurably small value. The transition from normal to the superconducting phase is often sharp and occurs within 10^{-2} to 10^{-4} K. This behavior is remarkably different from the steadily decreasing resistance of non-superconducting metals and suggests the existence of a physically different superconducting state. In pure metals the zero resistance state can be reached within a temperature range of 1 mK. In the case of impure metals the transition to the superconducting state may be considerably broadened. A transition width of $\approx$ 0.05 K was observed for impure tin. The resistivity ofa superconductor to direct current is zero as far as it can be measured. The estimates of the resistivity in the superconducting phase place it at less than $4 \times 10^{-25}\,\Omega$-m, which is essentially zero for all practical purposes. A striking way to demonstrate zero resistivity is to induce a current around a close ring of a superconducting metal.



Fig(1):Resistance versus temperature for low temperature

Experiments have been performed in which a 'persistent current' has run for over two and a half year without any measurable decay. The time dependence of the current *I* in the loop is given by

$$\mathbf{I(t) = I_o\, e^{-t/\tau}}$$

where $I_o$is the initial value of the current and *t* is the time which has elapsed since the supercurrent has been induced. The ratio of resistance *R* and self inductance L of the superconducting loop determines the time constant _ for the decay of the current. Above the critical temperature T_c the metal is in the normal state and resistance is proportional to T^5. In many metals the exponent is between 2 and 6, considerably different from the value of 5predicted by Bloch theory.

Critical temperature, T_c varies from superconductor to superconductor but lies between less than1 K and approximately 20 K for metals and metal alloys.

What is a Superconductor ?

"A **Superconductor** has **ZERO** electrical resistance **BELOW** a certain critical temperature. Once set in motion, a persistent electric current will flow in the superconducting loop **FOREVER** without any power loss."

Superconductivity is a phenomenon of exactly zero electrical resistance and expulsion of magnetic fields occurring in certain materials when cooled below a characteristic critical temperature. But if applied strong magnetic field the superconductivity property of materials is destroyed and material revert back to normal state, The materials exhibit superconductivity are called superconductor

Meissner effect :A superconductor will not allow a magnetic field to penetrate its interior. It causes currents to flow that generate a magnetic field inside the superconductor that just balances the field that would have otherwise penetrated the material. , causes a phenomenon that is a very popular demonstration of superconductivity. (See figure 2) The Meissner Effect will occur only if the magnetic field is relatively small. If the magnetic field becomes too great, it penetrates the interior of the metal and the metal loses its superconductivity.

Critical temperature (T_c): is the temperature at which the normal state of a conductor changes to superconducting state. critical temperature is different for different superconductors. Critical temperature depended on:

1- Purity of material.
2- Applied pressure on material.
3- Thickness of material.
4- Electrostatics charge on material.

We see that if the metals are pure the range of temperature at which its the resistivity goes to aero be very small while if the metals have impurity the range of temperature be large.

Critical temperature depended on pressure that if the pressure increases the critical temperature T_c deceases.

The effect of thickness at T_c if the matter is thin film we find that T_c decreases strongly compare with the same matter have large thick (bulk).