Super Conductors, its Classification and Properties

The Substances which can conduct electricity with zero resistance are known as Super Conductor.

Classification of Super Conductors:-

The classification of Super Conductors are based on the following different parameters:-

1) On the basis of material:-
Superconductor meterial are elements (i.e mercury or lead)
alloys (such as niobium-titanium, germanium-niobium and niobium nitride)
Ceramics (YBCO) and Magnesium diboride.
Super Conducting Pnictides (like fluorine doped LaO Fe As)
or Organic SuperConductors fullerenes and Carbon nanotubes.

2) On the basis of Critical temperature:-
A Super conductor is classified as high-temperature if it reaches a superconducting stage when cooled using nitrogen i.e at only $T_c > 77k$ or low temp. is more aggresive Cooling techniques are required to reach its critical Temp.

3) On the basis of the theory of Operation:-
The Super Conductivity is Conventional if it can be explained by the BCS theory or its derivatives, or unconventional otherwise other wise.

4) On the basis of responce to magnetic field:-
A Super Conductor can be classified as Type I, meaning it has a single Critical field, above which Super Conductivity is lost and below which the magnetic field is completely expelled from the Super Conductor.
The super Conductor is classified as Type II, meaning it has two Critical fields, between which it allows partial penetration of the magnetic field through isolated points.
These points are Called Vortices.
Furthermore, in multicomponent superconductors it is possible to have Combination of two behaviours, In that Case super Conductor is classified in Other type.

Properties of Super Conductors.

The properties of Super Conductors is varied from material to material that depends on heat Capacity and Critical temperature of the material and also depends upon Critical field, critical Current density at which Super Conductivity is destroyed.

As we see on the other hand, there is a class of properties that are independent of the underlying material.

All superconductors have exactly zero resistivity to low applied Currents when there is no magnetic field present or if the applied field does not exceed a Critical Value. The existence of these universal properties implies that Super Conductivity is a thermodynamic Phase, and thus possesses certain distinguishing properties which are largely independent of macroscopic details.

Super Conductors are also able to maintain a Current with no applied Voltage whatsoever, a property exploited in Super Conducting electro-magnets such as those found in MRI machines.

Now experiment has demonstrated that Currents in SuperConducting Coils Can persist for years without any measurable degradation.

Here the experimental evidence points to a Current life time of atleast 1 lakh years. The theoretical estimates for the life-time of a persistent current Can be exceed the estimated life-time of universe, depending on the wire geometry and the temperature. In practice, currents injected in Super Conducting Coils have persisted for more than 23 years in Super-Conducting gravimeters. In Such instrument, the measurment principle is based on the monitoring of the Levitation of a super conducting niobium sphere with a mass of 4 gram

In a Conventional Super Conductor, the electronic fluid Can not be resolved into individual electron.

Instead of it Consist bound pairs of electrons known as Cooper pairs.

The pairing is Caused by an attractive force between electrons from the exchange of Phonons.

The energy Spectrum of this Cooper pair fluid possesses an energy gap, it means there is minimum amount of energy (ΔE) that must be supplied in order to excite the fluid. Thus, if ΔE is larger than thermal energy of the Lattice, given by 'KT', where K is Boltzmann's Const and T is the temp, then the fluid will not be Scattered by the lattice.

The Cooper pair is thus a super fluid, meaning it can flow

In a class of Supperconductors known as type-II super conductors, an extremely low but non-zero resitivity appears at temperatures not too far below the normal superconducting transition when an electric current is applied in conjuction with a strong magnetic field, which may be caused by the electric current.

This is due to the motion of magnetic vortices in electronic superfluid, which dissipates some of the energy carried by the current.

If current is sufficiently small, the vortices are stationary, and the resitivity vanishes.

The resistance due to this effect is small as compared with that of non-super conducting materials, but must be taken into account in sensitive experiments.

However, as the temperature decreases far enough below the nominal super conducting transition, these vortices can become frozen into a disorded but stationary phase known as a **Vortex glass**.

Below this vortex glass transition temperature, the resistance of the material becomes truly zero.

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