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SUPERCONDUCTING MATERIALS AND ITS APPLICATIONS

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Abstract

The objective of this document is to explain the "Recent trends in Superconducting materials by the use of carbon nano tubes (CNT'S) .Carbon nano tubes (CNT'S) which are one dimensional (1D) molecular conductor. Tiny tubes of carbon may conduct electricity without any resistance. Ping Shing and coworkers at Hong Kong University of science and technology have found Nano tubes exhibit superconducting behavior below 20 Kelvin confirming that resistance free current can flow through pure carbon. The tubes would be the first superconductor to work at room temperature hence it conduct electricity and heat by lattice vibrations in the materials.

Index Terms:

(Superconducting materials electricity carbon nano tubes critical temperature,zero resistance).

Introduction

Superconducting is a phenomenon of exactly zero electrical resistance and expulsion of magnetic flux fields occurring in certain materials called superconductors when cooled below a characteristic critical temperature. It was discovered by Dutch physicist Heike kamerlingh onnes on April 18, 1911 in leiden. Superconductivity is a quantum mechanical phenomenon. It is characterized by meissner effect , the complete ejection of magnetic field lines from the interior of superconductors during its transitions into superconducting state. The electrical resistance of metallic conductor decreases gradually as temperature is lowered. In ordinary conductors, such as copper or silver, this decrease is limited by impurities and other defects. Even near absolute zero , a real sample of a normal conductor shows some resistance. In a superconductor, the resistance drops abruptly to zero when the material is cooled below its critical temperature. An electric current through a loop of superconducting wire can persist indefinitely with no power source.

Superconductivity occurs in wide variety of materials including simple elements including like tin, Aluminum , various metallic alloys, some heavily doped semiconductors and certain ceramic compounds containing planes of oxygen and carbon atoms. The latter case of compounds known as Cuprates are high temperature semiconductors. Superconductivity does not occur in noble metals like gold and silver or in ferromagnetic metals. In conventional superconductors, superconductivity is caused by a force of attraction between certain conduction electrons arising from the exchange of photons.

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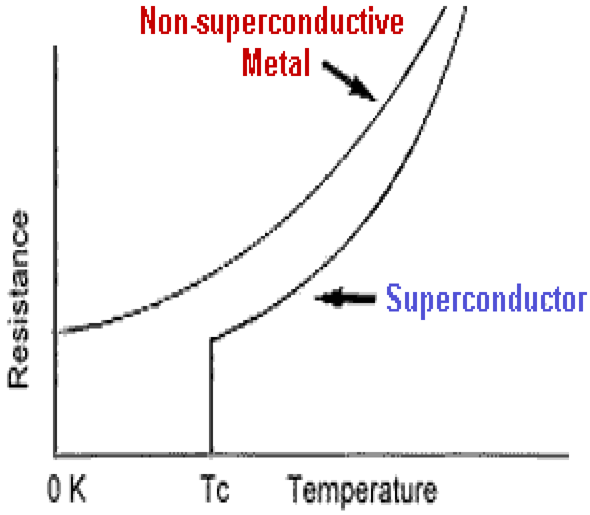


History of superconductivity:

Superconductivity was discovered on April 8, 1911 by Heike kamerlingh onnes who was studying the resistance of solid mercury at cryogenic temperature using the recently produced liquid helium as a refrigerant. At the temperature of 4.2kelvin, he observed that the resistance abruptly disappeared. He also observed the super fluid transition of helium at 2.2kelvin without recognizing its significance. Superconductivity was observed in several materials.

In 1913, lead was found to super conduct at 7 kelvin and in 1941 niobium nitride was found to super conduct at 16 Kelvin. In 1933, the important step occurred when meissner and ochsenfeld discovered that superconductors expelled applied magnetic fields, a phenomenon which has come to be known as meissner effect.

London theory – The first phenomenological theory of superconductivity was London theory. It was put forward by the brother's fritz and Heinz London in 1935, shortly after the discovery that magnetic fields are expelled from superconductors.

Also in 1950, Maxwell and Reynolds found that the critical temperature of a superconductor depends on the isotopic mass of the constituent elements. This important discovery pointed to the electron phonon interaction as the microscopic mechanism responsible for superconductivity.

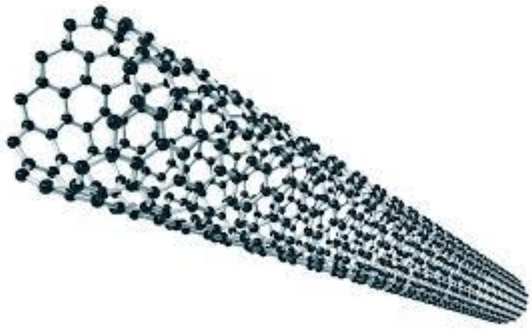
In 1957, the complete microscopic theory of superconducting was finally proposed by Bardeen , copper and Schrieffer. The BCS theory explained the superconducting current as a super fluid of copper pairs of electrons interacting through exchange of phonons. For this work, the authors were awarded the noble prize in 1972.

Example of superconductors :

Carbon nanotubes (CNTs) :

Tiny tubes of carbon may conduct electricity without any resistance at temperatures stretching up past the boiling point of water. The tubes would be the first superconductors to work at room temperature. At the moment no superconductor will work above about 130

Kelvin. But if a material could carry current with no resistance at room temperature, no energy would be lost as heat , meaning faster, lower power electronics and electricity could be carried long distances with 100 percent efficiently.



Nanotubes are the new superconductors

Sheng and colleagues detected superconductivity in single –walled carbon nano tubes- which are rolled up sheets of graphite – just 0.4 nanometers in diameter. "we believe this is the first time that superconductivity has been seen in individual carbon nanotubes" , sheng told physics web. Superconductivity has been seen in carbon nanotubes before, but it was due to the 'proximity effect'. This is an exotic phenomenon in which two superconductors can induce resistance- free current in certain materials sandwiched between them.

The nanotubes showed three telltale signs of superconductivity: the meissner effect, a superconducting gap and a super current. In the meissner effect, a superconductor placed in a magnetic field expels magnetic flux from its interior. "This is the acid test for superconductivity", sheng told physics web. The team used as SQUID magnetometer to measure the magnetic susceptibility of the carbon nanotubes, which is directly related to this internal flux.

The nanotubes were placed in a magnetic field after they had been cooled to 1.8 Kelvin, and the temperature was then raised to 50 Kelvin. This process was repeated for magnetic fields ranging in strength from .02 tesla to 5 tesla. Below 10 Kelvin, magnetic flux inside the nanotubes fell steadily as the field grew stronger, and was close to zero at 5 tesla. This effect was still evident as the temperature approached 20 Kelvin. Thos closely matches the predicted behavior of the meissner effect.

The electrons in conventional conductors move individually, but superconducting electrons move in pairs. "the energy needed to separate the paired electrons is known as the superconducting gap". This gap is further evidence of superconductivity. The third effect the team observed was a 'super current'. The data collected by sheng and colleagues are consistent with Bardeen-cooper-Schrieffer theory of superconductivity, which states that vibrations of the crystal lattice known as phonons- aid the free flow of paired electrons in superconductors.

Applications:

Superconducting motor to increase power density:

The field of electric motors has recently entered a new era. With the realization of using superconducting wire to replace conventional copper coils, motors are becoming more

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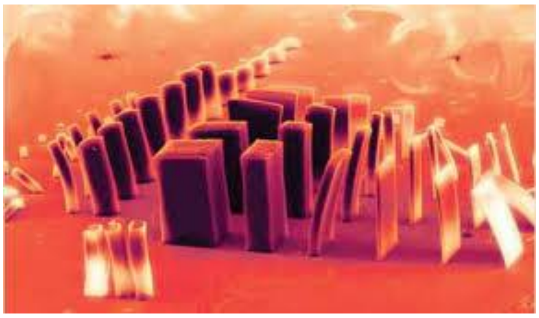
compact , more energy efficient and less expensive which will have advantage particularly for large industrial applications. Unlike copper coils, the niobium titanium (NbTi) inductor coils in this design have no electrical resistance, which is one of the greatest advantages of superconductors.

The major advantages of these motors are a high power volume density and a high torque volume density and less vibration than for conventional motors.

Carbon nanotubes super springs

For certain applications, mechanical springs are superior to electrochemical batteries. A spring's stored energy can be released quickly with high power density. Springs can be recharged many times without degradation and can hold stored energy without leakage. Carbon nano tubes springs are springs made of carbon nanotubes. They are an alternate form of high density, lightweight, reversible energy storage based on the elastic deformation of CNTs.

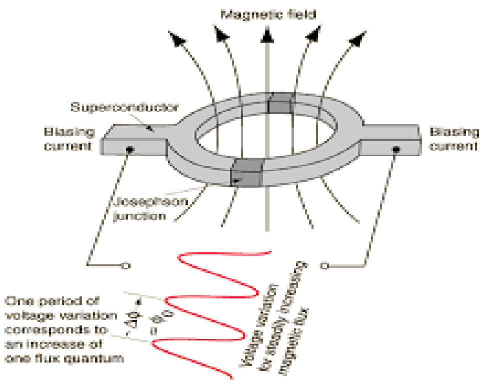


Thermal radiation sensors:

The CNTs are used in thermal radiation sensors for thermal emission of light rays or photons in space such as space satellites.

SQUID (superconducting quantum interference device):

A SQUID is a very sensitive device for measuring weak magnetic fields. It is capable of measuring magnetic field as low as 50 tesla. Due to their sensitivity, SQUIDS are widely used in research, biological studies and other ultrasonic electronic and magnetic measurements where faint signals cannot be sensed using conventional measurement



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Superconducting magnets:

Superconducting magnets are widely used in MRI machines, NMR Equipments, mass spectrometers, magnetic separation processes and particle accelerators. A superconducting magnet is an electromagnet made from coils of superconducting wire. Superconducting magnets can produce greater magnetic fields than all. Hence it is favourable to use.

CNTs can be used instead of tungsten wires in light bulb filaments because of its high withstand temperature and high superconductivity. The efficiency of the electric bulbs are increased and power is considerably decreased.

Conclusion

Carbon nano tubes have number of advantages and merits over other superconductors. CNTs can now add superconductivity to their repertoire of novel electronic and mechanical properties. Superconductivity have vast applications. At present the cost of other superconducting materials are increasing and size are also the faults too. The conduction will considerably increase and reduces the size of the conductor. Consequently the resistance of these materials are zero below 12 Kelvin , the CNTs will replace the defaults of other materials with its high capacity.

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