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# THERMODYNAMIC BEHAVIOUR OF SUPERCONDUCTING NANO MATERIALS

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is called a superconductor. Superconductivity is an important physical property of materials that occur at the nanoscale. The applications of achievable superconductivity are significant, potentially and a miracle change may be observed in their electronic structure. The temperature

at which this transition from normal to superconducting state occurrence in absence of magnetic field is known as transition temperature or critical temperature. In this present work we try to find the potential change and increase the superconductivity temperature of many materials and alloys.

**KEYWORDS:** Superconductivity, Cooper electron pairs, quantum computers.

**INTRODUCTION:** Superconducting materials have significant applications as low-loss current conductors, creating ultrahigh Magnetic field, and in microwave applications. Because of its enormous economic potential, it has been given increasing attention. There have been important research results and discoveries over the years, perhaps most noted by Nobel Prize awards to scientists in superconductivity research in 1913, 1972, 1973, 1987, and 2003. A group if "high temperature" superconductors made with layers of cooper oxides sandwiched between insulating filler material have been developed by materials scientists. This material reaches critical temperatures in the range of 130 K, the highest known critical temperatures to date. Previous studies on superconductors have established that while the critical temperature rises as the number of layers increase from one to three, it then drops off. The critical temperature has fallen below that of the single-layer superconductor by the time the number of layers rises to seven. It is previously suggested by scientists that the critical temperature increases between one and three layered materials is due to the ability of electron pairs to tunnel between layers of superconducting material. Ever since the phenomenon of superconductivity was discovered, researchers have been eager to reveal the mystery of its physical mechanism. After years of studies, Bardeen, Cooper, and Schrieffer believed that superconductivity originated in the electron and lattice interactions. This theory is known as the BCS theory. However, as long as the interaction of the electron and lattice is strong enough, the indirect effect of attraction between the electrons is likely to exceed the coulomb repulsion, so that the electron pairs may have a net amount

of interattraction. The result is that a bound state can be formed between them. This bound state is an electronic pair formed by two pairs of electrons, called Cooper pairs. From the momentum space, the two electrons are set with a total momentum of K. Cooper's work showed that when <u>K</u>=0 the binding energy reaches its maximum, and electron pairing has the lowest energy. From the momentum space, the two electrons in Cooper pairs may involve a quantum state with a momentum that is equal in size and opposite in direction, and also include those with an opposite spin. In this case, the Cooper pairs have

an energy that is less than that of the two electrons in "their own action" and thus are more stable. Superconductors with the critical temperature below the liquid helium temperature are known as low-temperature superconductors. After properties of researchers discovering mercury, discovered superconducting characteristics in tin, lead, and many other metallic elements and alloys, as well as compounds, but their critical temperatures have remained very low (below the temperature of liquid helium). Through years of efforts, now discovered metallic researchers have most elements exhibit superconductivity. By the introduction of special techniques (such as highpressure technology, technology in precipitation into a thin film at low temperature, and very rapid cooling), those metals that were once believed to be unable to turn into superconductors have achieved the state of superconductivity under certain circumstances. The newly discovered superconductors are found widely throughout the periodic from lighter elements boron and lithium to the transition metal uranium series, and many complexes of transfer salts. Here, C<sub>60</sub> may have a greater potential for development because of its greater elasticity, making it easier to be molded than the oxide ceramic, which has a hard and crisp texture. Moreover, it has a larger critical current,

critical magnetic field, and coherence length. These characteristics make  $C_{60}$  superconductors more likely to be put into practical use.  $C_{60}$  is hailed as a "star" of new materials in the twenty-first century, For it has demonstrated a wide range of novel features and application prospects in machinery, light, electricity, magnetism, and chemistry. Some researchers predicted that the giant  $C_{240}$  and  $C_{540}$  once synthesized successfully, are likely to become superconductors at room temperature.

#### **MAGNETIC NANOCLUSTERS:**

Recent theory proposed that globular clusters with a specific number of superconducting electrons will show superconductivity at relatively high temperatures. This theory may be established for some simple Metal clusters such as aluminum, gallium, zinc, and cadmium. For example, Ga<sub>56</sub> was predicted

with a critical temperature of approximately 150 K (-123<sup>o</sup>C). Mesh material composed of such clusters can be formed on the surface and can carry the superconductor current at higher temperatures. In 1984, W. Knight discovered the existence of the so-called shell structure, which is the basis of this phenomenon. At that time, this event did not arouse the attention of the superconductivity research community. Rather, it was largely ignored because of research on the cuprate HTS discovered in 1986, a hot topic at the time. At present, research on nanoclusters is steadily developing. It quite possible that superconductivity will be observed in these clusters. Experiments in this area require artificially measuring the selected cluster concerning its excitation low temperatures (above the critical temperature). spectrum at Superconducting pairing mechanisms Will lead to significant differences in the excitation spectrum at temperatures such as the critical temperature. Relevant technologies have been developed in this respect, including mass spectrometry, generation of an energy beam at different temperatures, as well photoelectron spectroscopy. Another noteworthy achievement is the as growth of isolated clusters in the matrix and molecular crystals, which can form an orderly three-dimensional lattice.

### NANOSUPERCONDUCTORS:

Nanometer-sized materials can be used to make ultrasmall superconducting devices, such as quantum computing devices. Currently, use of the nanosuperconducting Josephson junction as a qubit is an ideal candidate among a number of quantum bits.

The production and control of the stable qubits system is a key issue in the practical use of current quantum information and the physical implementation of quantum computing. To achieve practical use of the quantum computer in physics, we need to organically integrate universal quantum logic gates, to keep quantum entanglement between qubits, and to be able to manipulate them. In computer the role of the Josephson junction covers two aspects: one is to separate the superconducting phases on the right and left sides and the second is to allow superconducting cooper pairs to come through in the form of

electron tunneling. Superconducting current coming through the Josephson junction is determined by the superconducting phase difference between the left and right sides  $\Upsilon^{\gamma}$ . When the phase difference is zero or an integer multiple of  $2_{II}$ , the current is zero and the system has the lowest energy. The Josephson junction energy is expressed as  $-E_j \cos_Y J^{-E\cos_Y}$ . Interestingly, as an external magnetic field is applied perpendicular to it, the magnetic field will cause an increase of one phase in superconducting quantum wave function along the direction of the ring. Mathematically, this increased phase is expressed as the line integral of vector spaces, equivalent to the magnetic flux coming through the superconducting rings. Persistent current can produce a magnetic flux  $\Phi_{eff}$ =LI $\Phi_{eff}$  = LI. Here, L is the self-inductance of superconducting rings. The Josephson junction has a superconducting phase difference that satisfies the equation:



Shows a typical superconducting single-electron device.



In general, we can write the following Hamiltonian to describe it:

 $H=4EC(n^{-}ng)^{2}-E_{J}\cos\theta$ (3)

Here, *n* represents the charge amount on island described in the number of cooper electron pairs.  $\theta^{\theta}$  is the superconducting phase of the central island.  $n_g$  is the equivalent amount of charge caused by the gate voltage. Because  $\theta^{\theta}$  and *n* are conjugates, and because the contribution that can be obtained from Josephson energy is actually+1 or -1 in the number of cooper electron pairs on the island:

$$H = \sum_{n} 4E_{\rm C}(n - n_{\rm g})^2 |n\rangle \langle n| - \sum_{n} E_{\rm J}(|n + 1\rangle \langle n| + |n - 1\rangle \langle n|)$$
(4)

As  $n_g$  changes between 0 and 1, the lowest two energy states are n=0 and n=1. If we consider only two states, n=0 and n=1, then it can be viewed as two-level state. To simplify the infinite charge states into two, we must widen the energy gap for each energy state. To achieve this, we require  $E_c \gg E_J$ .

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