Constitution of a molecular structure that hardly generates a non-free electron orbital region is effective for the creation of superconductors with higher Tc

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ABSTRACT

The conventional theory explains that the electric resistance is caused by the scattering of free electrons by lattice vibrations. However, this theory is insufficient to explain the phenomenon that electrical resistance decreases under ultrahigh pressure, despite using the same material with the same lattice vibration. It was assumed that the elaboration of an essentially new theory of electrical resistance would lead to the clarification of the theory of superconductivity. In the present study, we started from the idea that the essence of the electrical resistance is that the lattice vibration generates non-free electron orbital regions, which induces scattering of free electrons. This consideration has led to the conclusion that the establishment of molecular structures that hardly form non-free electron orbital regions is effective for the creation of superconductors with higher superconducting transition temperature (Tc).

INTRODUCTION

We have conducted this research aiming at contributing to the creation of superconductors with higher superconducting transition temperature (Tc).

The conventional theory explains that the electric resistance due to heat is generated by the scattering of free electrons caused by lattice vibrations. However, this is insufficient to explain the phenomenon that electrical resistance decreases under ultrahigh pressure, despite using the same material with the same lattice vibration. As the decrease in electrical resistance and the increase in Tc under ultrahigh pressure constitute a series of phenomena, it was assumed that the elaboration of an essentially new theory of electrical resistance due to heat would lead to the clarification of the theory of superconductivity.

Based on the appearance of metallic bonds, which is a commonly known, we assumed that there is an adhesion force in the bonded electron cloud, like the surface tension of water. In ordinary conductive materials, the lattice vibration randomly generates a non-free electron orbital region, at the center of the lattice, which scatters free electrons and causes electrical resistance. Since even at identical lattice vibration the lattice is compressed and the interatomic distance is shortened under ultrahigh pressure, we assumed that non-free electron orbital regions are less likely to be generated. From the above consideration, we concluded that the establishment of molecular structures that are less prone to the generation of non-free electron orbital regions is effective for the creation of superconductors with higher Tc.

METHODS

The following well known four phenomena were considered.

1) Appearance of a metallic bond (Fig. 1(a)).
2) The phenomenon of a sudden drop in electrical resistance to zero at Tc as the temperature is lowered (Fig. 1(b)).
3) The phenomenon that Tc increases under ultrahigh pressure (Fig. 1(b)).
4) The phenomenon that electrical resistance decreases under ultrahigh pressure (Fig. 1(b)).

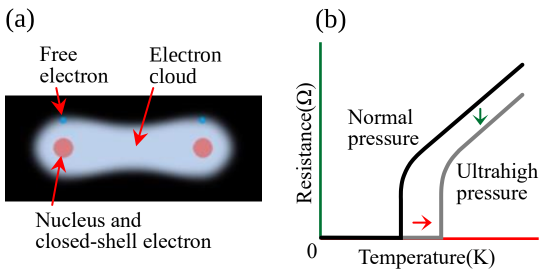

Figure 1. Generally well known phenomena. (a) Appearance of a metallic bond. (b) Graphs of superconducting transitions at normal and ultrahigh pressure.

DISCUSSION

Looking at the generally well known appearance of a metallic bond, the bonded portion of the electron cloud extends outward (Fig. 2(a)) from the electron cloud of a single atom (Fig. 2(b)), suggesting that an adhesion force is present in the bonded electron cloud, which is similar to the surface tension of water.

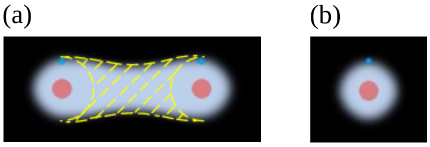

Figure 2. Generally well known phenomena. (a) Yellow-shade area represents the part of the electron cloud that extends outward from the single-atom electron cloud (b) in a metallic bond. (b) Electron cloud of a single atom.

Taking into account the above, if we consider the state of a conductor in thermal oscillation (Fig. 3(a)), when accidentally all adjacent atoms move outward, a non-free electron orbital region is generated at the center of the lattice (Fig. 3(b)).

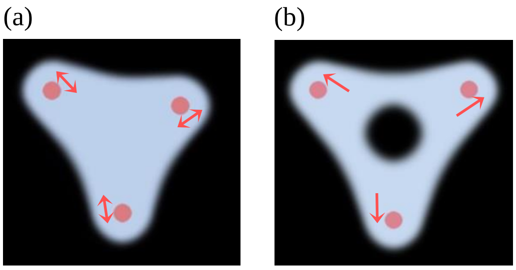

Figure 3: (a) State of thermal oscillation of a conductor. (b) A state where the non-free electron orbital region is generated at the center of the lattice.

In an ordinary conductor, moving free electrons are scattered by non-free electron orbital regions randomly generated at the center of the lattice (Fig. 4), resulting in causing electrical resistance. The electrical resistance is proportional to the size of the non-free electron orbital region.

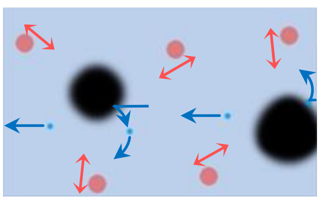

Figure 4: Free electrons in the state of being scattered via non-free electron orbital regions.

The “interatomic distance” and the “size of non-free electron orbital region” are represented in Figs. 5(a) and 5(b).

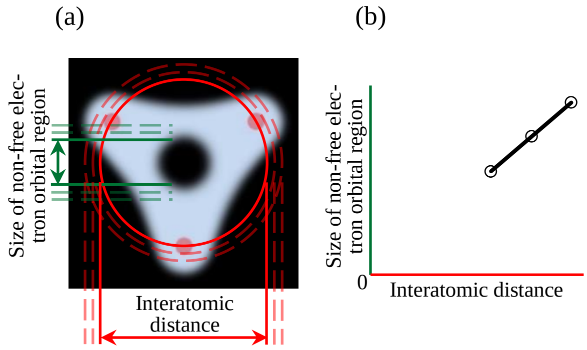

Figure 5. (a) Relationship between “interatomic distance” and “size of non-free electron orbital region”. (b) Graphical representation of (a).

If the “interatomic distance” approaches a certain value, by the adhesion force of the electron cloud, which is similar to the surface tension of water, the “size of non-free electron orbital region” suddenly drops to zero, as shown in Figs. 6(a) and 6(b). Fig. 6(b) resembles closely the graph of a superconductor where the electrical resistance suddenly becomes zero at Tc.

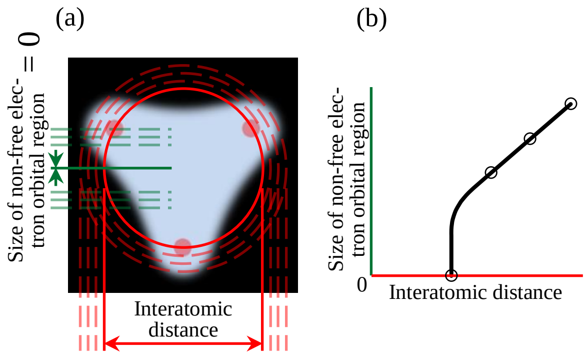

Figure 6. (a) Relationship between “interatomic distance” and “size of non-free electron orbital region”, showing the state where the “size of non-free electron orbital region” becomes zero. (b) Graphical representation of (a).

The decrease in electrical resistance under ultrahigh pressure cannot be explained by the scattering of free electrons due to lattice vibrations as suggested by the conventional theory. The reason is that under ultrahigh pressure the lattice is compressed and becomes smaller. If the lattice vibration is the same but the lattice itself is smaller, the probability that free electrons can pass through without being scattered by the lattice vibration decreases. In other words, it cannot be explained unless the probability of scattering free electrons increases and the electric resistance increases, which suggests that the lattice vibration does not directly scatter the free electrons. The essence of the electrical resistance due to heat is that the lattice vibration randomly generates non-free electron orbital regions, at the center of the lattice, which induces scattering of free electrons.

Under normal pressure, non-free electron orbital regions are randomly generated at the center of the lattice due to lattice vibration (Fig. 7(a)), but under ultrahigh pressure, where the lattice is compressed and the “interatomic distance” is reduced, the “size of non-free electron orbital region” decreases and so does the electrical resistance. If the pressure is further increased, non-free electron orbital regions are no longer generated (Fig. 7(b)). In other words, under conditions above a certain level of ultrahigh pressure and below a certain level of lattice vibration, no non-free electron orbital region is generated and the conductor becomes a superconductor. Therefore, the phenomenon where electrical resistance decreases and Tc increases under ultrahigh pressure can be explained by this concept.

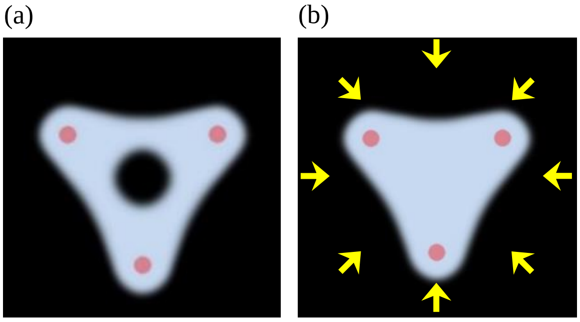

Figure 7: (a) State of formation of a non-free electron orbital region at the center of the lattice. (b) Lattice is compressed via ultrahigh pressure, the interatomic distance is reduced, and no non-free electron orbital region is generated.

CONCLUSIONS

This study concludes that the establishment of molecular structures that hardly generate non-free electron orbital regions at the center of the lattice due to lattice vibrations is effective for the creation of superconductors with higher Tc.

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