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Covering of conductors can aid in problems related to room-temperature superconductivity

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High-temperature superconductors are required in many fields of modern technology. However their widespread application is prevented by complexity in creation of low consistent temperature for superconductors and labor expenses in their manufacturing and operation. Electrical resistance was measured for a number of metallic conductors, which were coated with materials of different compositions. It was found that when nichrome wires were covered with clean bone glue, there was a conspicuous decrease in this resistance; with conductors containing iron and covered with clean bone glue, the resistance decreased to zero.

Keywords: Coated metallic conductors, room-temperature superconductivity

Introduction

Many useful mechanisms and devices are not created due to the problem of room-temperature superconductivity. Superconductors should be cooled by liquid nitrogen that considerably complicates their use.

However, my analysis of the literature has allowed concluding that for occurrence of superconductivity the low temperature is not obligatory. The following pieces of evidence support the above hypothesis. The discovery of high-temperature superconductivity in the mid-1980s (Gerber, Anselmetti, Bednorz, Mannhart, and Schlom, 1991; Hawley, Raistrick, Beery, and Houlton, 1991) overthrew the idea of temperature being a major factor in producing superconductivity. It became clear that a great deal depends on the composition of the doping used in such conductors (Gerber et al., 1991; Hawley et al., 1991; Amato, 1991). Studies of the internal structure of cuprates and pnictides led researchers to the idea that a superconductor is a hamburger, in which the electric current flows through the 'meat',while the 'buns' act as a supplier of electrons (Collins, 2009). The meat in those crystal sandwiches is represented by layers of copper oxide or iron pnictides, composed of alternating layers of atoms.

Examination under high magnification of the thin films that cover the crystal substratum revealed that the cuprate coating consists of spiral ladders with a screw displacement; this structure produced twisting in the lines of the magnetic field and facilitated high-temperature superconductivity (Garwin, 1991). In the CuO_2 layers, all the atoms were at almost the same level. However, in the FeAs layers, the arsenic atoms were situated above or below the iron atoms, and four arsenic atoms, surrounding each iron atom, were located at the tops of a tetrahedron (Kamihara, Watanabe, Hirano, and Hosono, 2008; Matsuishi, Inoue, Nomura, Yanagi, Hirano, and Hosono, 2008). The crystal lattices of recently synthesized superconductors also have a tetragonal structure (Imamura, Mizoguchi, and Hosono, 2012; Scheidt, Hathwar, Schmitz, Dunbar et al., 2012; Engelmann, Müller, Nenkov, Schultz et al., 2012).

Approaching the critical temperature for creation the tetragonal structure appears to be an important factor in the superconductivity of pnictides (Kamihara et al., 2008, Matsuishi et al., 2008; Imamura et al., 2012). It appears likely that the pyramidal structure protects the conductor from the noise produced by electromagnetic and sound waves, which cause oscillations in the positive ions and thereby hinder the flow of electrons. It has long been known that placing conductors within a pyramid increases the temperature at which superconductivity appears. A number of studies have investigated the changes in the long-range stripe-similar sequence at the critical temperature, which promotes the occurrence of high-temperature superconductivity (Daou, Chang, LeBoeuf, Cyr-Choiniére et al., 2010). Quasiparticle interference, in which particle-like behavior disappears as a result of defects in a material, creates standing waves and promotes superconductivity (Moler, 2010). Based on the above observations, one can conclude that when a conductor is isolated from electromagnetic and sound waves, the positive ions in the conductor's crystal lattice go into a dormant state and do not impede the flow of electrons. Therefore, it was decided to begin testing various materials as a covering for conductors.

Methods

To determine the possible influence of a covering on the conductivity of metals, we covered metal conductors with bone glue, which were used by carpenters over the past century for gluing wood. Bone is a calcified connective tissue, composed of cells within a solid basic substance. Approximately 30% of this basic substance consists of organic compounds, mostly in the form of collagen fibers, and the remaining 70% is inorganic. The major inorganic component of bone is hydroxyapatite Ca_{10} $(PO_4)_6$ $(OH)_2$, but bone also contains various amounts of sodium, magnesium, potassium, chlorine, fluorine, carbonates, and citrates (Taylor, Green, and Stout, 1997). Several compounds, including pure bone glue, were tested to determine the optimum coatings for the conductors.

Instruments

For the conductors, it was used mostly nichrome and iron wires and also a foreign-made immersion water heater with a stainless steel sheath (Weltor, Inc.). To measure the resistance of the conductors, a household multimeter, DT-831 (ASD-Electro, Inc.), was used with a range of 200 ohms and resolution of 0.1 ohm. The conductor coatings: pure bone glue; a dried mixture of superphosphate $Ca(H_2PO_4)_2$ and chalk ($CaCO_3$); a mixture of bone glue and $CaCO_3$ + $Ca\ (H_2PO_4)_2$; a mixture of bone glue and superphosphate $Ca\ (H_2PO_4)_2$ were examined using a scanning electron microscope, EVO-40 (Carl Zeiss, Inc. Germany).

Making bone glue and mixtures

We made the pure bone glue coating using a thermostatic water bath (in capacity with water capacity with glue and water is placed) by fusing bone glue granules (Bone Glue, Usolsk Glue Factory, Russia) in water at a weight ratio of 1:1 and at a temperature of 65-70°C. The bone glue mixtures were produced using the thermostatic water bath by mixing the bone glue with salts or Moment rubber glue (produced of Henkel AG & Co. KGaA, Germany).

Coating variants

First, the resistance of 0.2-mm-diameter nichrome wire was measured. This wire was then dipped into the following: (1) "Moment" rubber glue; (2) bone glue, which had been melted in the thermostatic water bath; (3) humidified superphosphate Ca $(H_2PO_4)_2$, which was mixed with the melted bone glue in the proportion of 50:50; (4) a mixture in which three-quarters of the volume was $CaCO_3$ + Ca $(H_2PO_4)_2$ and one-quarter was melted bone glue; (5) a mixture in which three-quarters of the volume was melted bone glue and one-quarter was "Moment" rubber glue. The pieces of wire were immersed in the glue for no longer than one minute. Resistance was measured in a 1.5-mm-diameter iron wire as well as in the water heater, in which the diameter of the stainless steel sheath was 4.0 mm. Then, the pieces of wire were immersed in the melted bone glue. After being removed from the glue, the conductors were air-dried for six hours, following which their resistance was measured. After removal from the water bath, the thickness of bone glue at water heater was 0.5 mm. Then the thickness of the bone glue layer was decreased to 0.05 mm by immersion in the hot water. After drying the conductor again, we measured the resistance of the sheath, then dipped the conductor in the "Moment" rubber glue, dried it, and again measured the resistance. Further, several household magnets were attached to the sheath and the resistance was measured.

Statistics

Data were analyzed using the STATISTICA statistical package (6.0 Version). The results were expressed as means and with a 95% confidence interval. The Kolmogorov-Smirnov test was employed to analyze the normal distribution of the variables ($p < 0.05$). The data followed a normal distribution and were therefore analyzed using parametric tests. Student's *t* test for dependent samples was utilized to assess the differences in the resistance of electric current in the nichrome wires before and after the coverings were applied. For graphical representation of the data, non-metric multidimensional scaling ordination was carried out using the Bray-Curtis distance. Before calculation, the data were transformed according to the method adopted by Clarke and Green (1988). For each variant, 5-11 nichrome wires were coated. In all, 40 wires were employed.

Results

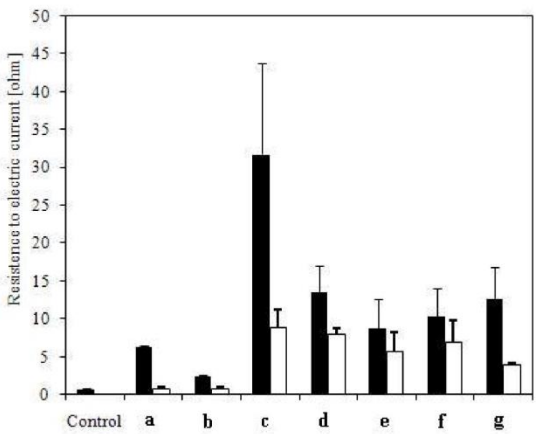
It was found that in a 0.2-mm-diameter nichrome wire, which was coiled into a spiral with a 7-mm diameter and covered with the experimental composition, the electrical resistance did not decrease at ordinary room temperature. The electrical resistance likewise showed no reduction when the wire in the spiral was stretched to twice its original length. This was probably due to the magnetic field generated by the electric current as it passed through the spiral wire. It has long been known that magnetic fields destroy superconductivity (Collins, 2009). The experimental coatings decreased the resistance after the wire was wound into large coils (100.0 mm in diameter) or folded in the form of a zigzag. With the iron wire, the resistance decreased to zero (Figure1).

The initial resistance of the water heater with the stainless steel sheath was 6.3 ohms; after the sheath was coated with a 0.5-mm-thick layer of bone glue, resistance in the sheath decreased to zero at room temperature. The bone glue is an insulator. Electrical resistance in a 1.5-mm-diameter iron wire after the bone glue as well decreased to zero at room temperature (Figure 2).

Thinning the layer of bone glue to a thickness of 0.05 mm caused the resistance in the sheath to increase to 4.5 ohms. However, after the heater was covered with "Moment" rubber glue and then allowed to dry, the resistance once again decreased to zero. Placing ordinary magnets on the heater did not affect its electrical resistance. Five days after the conducting the resistance measurements, the tests were repeated, and the results obtained were close to the initial ones.

FIGURE 1. VARIATIONS IN THE ELECTRICAL RESISTANCE (OHMS, 20°C) OF CONDUCTORS WITH VARIOUS COATINGS

The control instrument reading in the experiments was with the absence of a conductor. (*a*) Resistance in the 4.0-mm-diameter sheath of the water heater before (black) and after (white) coating with bone glue; (*b*) resistance in a 1.5-mm-diameter iron wire before (black) and after (white) coating with bone glue; (*c*) resistance in a 0.2-mm- diameter nichrome wire before (black) and after (white) coating with bone glue; (*d*) resistance in a 0.2-mm- diameter nichrome wire before (black) and after (white) coating with Moment rubber glue; (*e*) resistance in a 0.2-mm-diameter nichrome wire before (black) and after (white) coating with a mixture of bone glue and Moment rubber glue; (*f*) resistance in a 0.2-mm-diameter nichrome wire before (black) and after (white) coating with a mixture of salts Ca $(H_2PO_4)_2$ + $CaCO_3$ and bone glue; (*g*) resistance in a 0.2-mm-diameter nichrome wire before (black) and after (white) coating with a mixture of superphosphate $Ca(H_2PO_4)_2$ and bone glue.



There was a statistically significant difference between the initial electrical resistance in the nichrome wires and the resistance after coating: *t (40)= 3.409; df = 39; p = 0.0015*. When the nichrome wire was covered with bone glue, the difference between the initial electrical resistance in the nichrome wires and the resistance after coating was as follows: *t (11) = 2.32; df = 10; p = 0*.043. When the nichrome wire was covered with Moment rubber glue, the difference between the initial electrical resistance in the nichrome wires and the resistance after coating was as follows: *t (10) = 2.88; df = 9; p = 0.018*. Non-metric multidimensional scaling analysis showed that the coating of bone glue or mixture of bone glue with Ca $(H_2PO_4)_2$ + $CaCO_3$ produced the greatest decrease in resistance in the nichrome wire (Figure 3).

Under a scanning electron microscope, it was evident that the various coatings showed defects in their structure; these defects were 0.5-40.0 μm in size (Figure 4). The coating that provided the greatest decrease in resistance in the nichrome wire (bone glue) had defects that measured about 1.0 μm (Figure 4).

FIGURE 2. MEASURING ELECTRICAL RESISTANCE (OHMS, 20°C) IN A CONDUCTOR CONTAINING IRON

(*a*) The control instrument reading in the experiments was with the absence of a conductor; (*b*) electrical resistance in the sheath of the water heater before the covering was applied; (*c*) electrical resistance in the sheath of the water heater after the bone glue was applied; (*d*) electrical resistance of the covering; (*e*) electrical resistance in a 1.5-mm-diameter iron wire before the covering was applied; (*f*) electrical resistance in a 1.5-mm-diameter iron wire after the bone glue was applied.

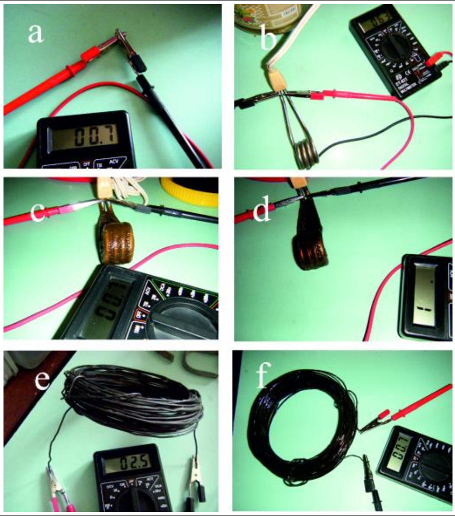


FIGURE 3. NON-METRIC MULTIDIMENSIONAL SCALING ORDINATION ANALYSES OF ELECTRICAL RESISTANCE IN THE NICHROME WIRES BEFORE AND AFTER THE DIFFERENT COATINGS WERE APPLIED

Bonbef = befor covering of bone glue, bonaft = after covering of bone glue, mombef = befor covering of Moment rubber glue, momaft = after covering of Moment rubber glue, sulbef = befor covering of a mixture of salts and bone glue, sulaft = after covering of a mixture of salts and bone glue.

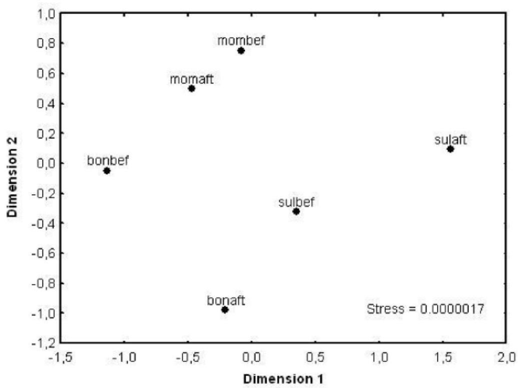
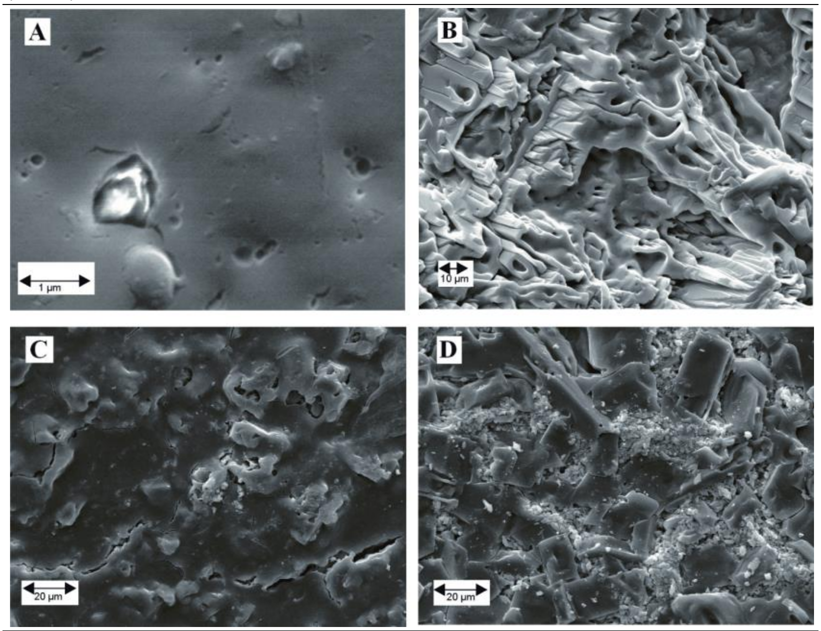


FIGURE 4. VIEW OF THE COATINGS AT HIGH MAGNIFICATION

(a) The pure bone glue had cavities owing to microbubbles of air; (b) dried salts—Ca $(H_2PO_4)_2$ + $CaCO_3$—obtained by mixing with water under carbon dioxide aeration show no structural disturbances; (c) the mixture of bone glue and salts—Ca $(H_2PO_4)_2$ + $CaCO_3$—displays disturbances in its structure; (d) the mixture of bone glue and superphosphate—Ca $(H_2PO_4)_2$—had disturbances in its structure.



Discussion

High-temperature superconductors are used in many fields of modern technology. However, several obstacles prevent the widespread use of such superconductors. The first of these is the complex issue of creating constant low temperatures that allow the superconductors to function properly (Collins, 2009). It has been reported that superconductors containing iron (pnictides) require lower temperatures than cuprates (Kamihara et al., 2008).

There is an ongoing search for new materials that can function as superconductors (Hawley et al., 1991; Amato, 1991); however, solving the problem of room-temperature superconductivity has reached an impasse. Practically all existing inorganic substances have been subjected to trials as part of this search, but no superconductivity at room temperature has been found (Comarov, 2012). Previous research efforts have examined the phenomenon of superconductivity particularly with regard to the doping used in the conductors (Gerber et al., 1991; Hawley et al., 1991), and it has emerged that such a doping should certainly not be metallic (Kamihara et al., 2008; Scheidt et al., 2012). However, no tests have been conducted on a coating similar to bone tissue.

In the study metallic conductors were covered with several kinds of coatings that had essentially a similar composition to that of the cranial bones. The received results showed that when nichrome wires were coated, there was a significant reduction in the electrical resistance. The greatest reduction in resistance was observed when the wires were covered by clean bone glue. When this coating was used on iron conductors, the electrical resistance was reduced to zero.

Conclusion

The study has demonstrated that when coated with bone glue, metallic conductors exhibit considerably decreased electrical resistance at room temperature; when the conductor contained iron, the resistance fell to zero. Covering conductors with a thin layer of bone glue plus "Moment" rubber glue imparted elasticity, resistance to impact, and stability to moisture and magnetic fields without loss of superconductivity. The results of this study demonstrate that it is possible to create a covering for conductors that decreases electrical resistance to zero.

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