INCREASED CRITICAL CURRENT AND IMPROVED MAGNETIC FIELD RESPONSE OF BISCCO MATERIAL BY SURFACE DIFFUSION OF SILVER

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ABSTRACT

We have developed a procedure of increasing the critical current of **BISCCO** ceramic superconducting material , the value of the critical current is increased by 30 %. Moreover the degradation of the critical current with the applied magnetic field had been decreased. The procedure consists of applying a thin layer of silver to the surface of the conductor. The details of the procedure and the improved performance are discussed . This procedure has great significance for any future application of HTSC materials where high current carrying capacity is necessary. It will therefore be important in the application of HTSC materials to SSC high current leads.

INTRODUCTION

The application of high transition temperature superconductors, (HTSC), for practical purposes has been limited by their low critical currents and the deterioration of this critical current on the application of a magnetic field. Although some HTSC materials have been produced which have critical currents of the order of $10^5 A/cm^2$, they can only be made in films or small laboratory quantities, and can not be produced in moderate quantities because of the slow rate and cumbersome and unreliable process by which they are produced. The forms of HTSC materials which can be produced in quantity are bulk sintered components which generally are produced from a powder. In general, the powder is mixed with an organic binder which is then carefully removed. The surface tension of the binder provides the necessary force to bring the powder grains together so that they can be sintered once the binder is eliminated. The ultimate limitation on J_c is thought to be the weak link behavior which develops between the powder grains during sintering (1). This behavior is enhanced, or may be a result of the extremely short coherence length in these materials. In long length of the material, the critical current of the HTSC is limited by micro cracks, and the alignment of the grains since their conductivity is anisotropic. To a certain degree those micro cracks can be filled by the addition of silver powder to the HTSC powder before the binder is added and before sintering (2,4). In addition, the silver may provide pinning centers for quantized magnetic flux lines and thus diminish flux motion which results in resistivity in superconducting materials. The addition of silver, however, increases the thermal conductivity of the material which in some applications is an undesirable effect.

We have found a method which enhances the critical current density in HTSC sintered material both at zero and finite magnetic field. It consists of an application of a small quantity of silver to the surface of the HTSC bulk material. This method does not significantly increase the thermal conductivity of the material.

Our aim is to build electrical power leads to conduct current between 70K and 4.5K. For this high critical currents and low thermal conductivity are of importance. In our application the HTSC material is in the form of long rods of either rectangular or circular cross section. Those rods are reinforced for mechanical stability and provided with low electrical resistance contacts which on one end connect to copper leads and on the other to conventional low temperature superconducting leads such as copper clad niobium titanium.

EXPERIMENTAL PROCEDURE

A long rectangular rod of BSCCO material, characterized as 95% 2223 phase, of length 8 cm and 0.3cm x 0.3cm is cut into two halves. Thus the rods are identical except for the treatment of one of the rods as described below.

The surfaces of each rod are treated by using very fine sand paper to introduce an uncontaminated surface. Then one of the rods is coated with a thin layer of silver. During the heat treatment, the silver layer diffuses into the HTC grains.

We then apply contact pads for current and voltage leads to both rods in order to measure their critical currents by means of the conventional four point method. Several methods are conventionally used for this purpose (5-9). Those are pressed indium contacts, ultrasonically soldered bonds, silver paste which is then baked in and soldered to, sputtering, metal sprayed, and silver vapor deposition. In practical application the contact resistance should be minimal to avoid heating of the sample and consequently quenching it.

The area of each silver pad on any rod was approximately 0.3cm x 0.3cm. To make the contact between the metallic conducting wire and the High T_c material we apply Supersolder (10), a low temperature soldering alloy developed by the ZerRes Corporation. We found this alloy to have a contact resistance which is lower by a factor of three from that of conventional solder contacts between the HTSC deposited silver and copper.

RESULT AND DISCUSSION

We measured the critical current of both the silver surface coated and the uncoated rod by means of the conventional four probe technique at 77K. The results are shown in Fig. 1. The critical current of sample #1, without silver coating, as seen from fig(1), is 20 A, i.e. the critical current density is 250 A/cm^2. The value of the critical current of the second rod, the silver coated one, is about 30 A, i.e. the current density is 370 A/cm^2.The coating had the effect of increasing Jc by 30%.

Fig. 2 shows the current-voltage characteristics of the silvered rod in various magnetic fields.

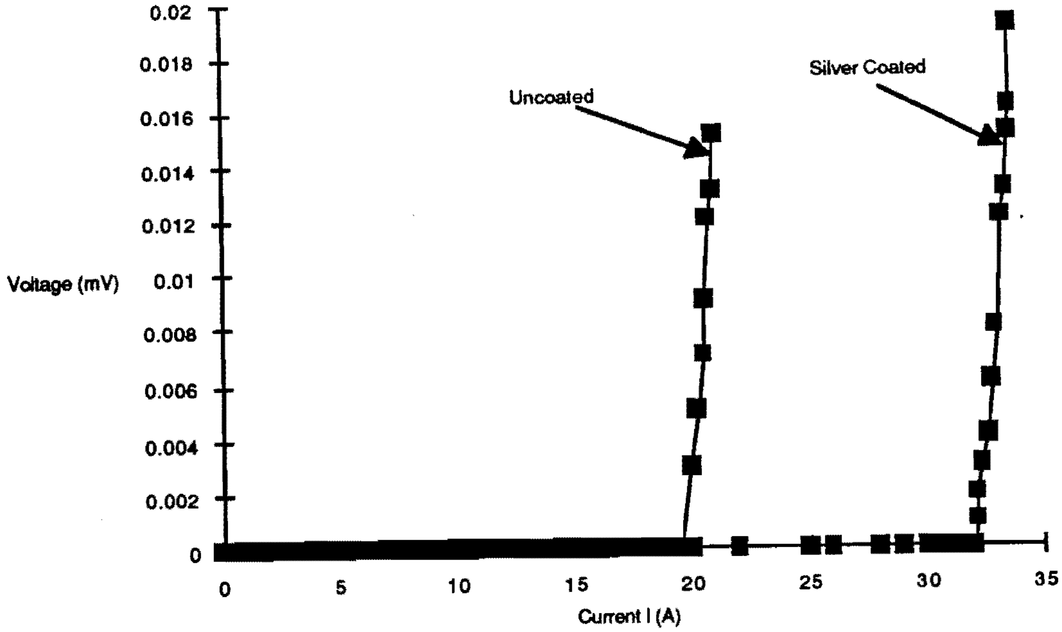

Figure 1. Current voltage characteristics of silver coated and uncoated rods.

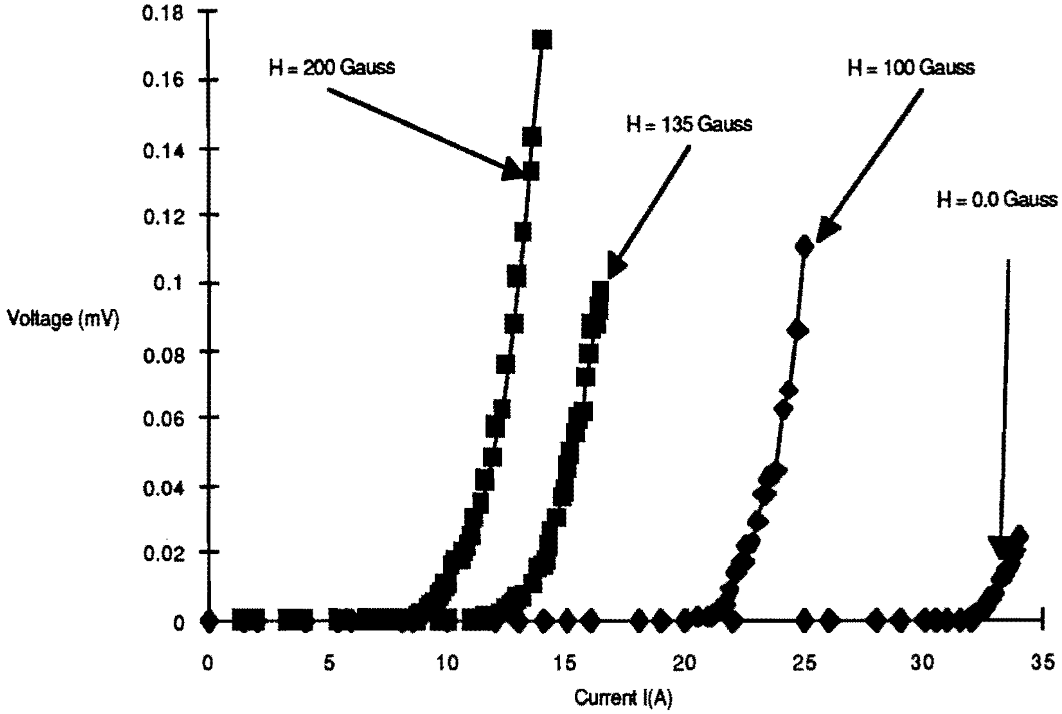

Figure 2. Current voltage characteristics of the silvered rod in various magnetic fields.

Fig. 3 shows the comparisons of the critical currents of both the silver coated and the uncoated rod in a magnetic field at 77K. At 100G the critical current density decreases from 370 A/cm^2 to 250 A/cm^2.Its behavior is greatly superior to that of an uncoated rod where the critical current decreases from 250 A/cm^2 to 144 A/cm^2 in a magnetic field of 100G.

Several attempts have been made to increase the critical current density of the HTSC material by mixing different materials with the HTSC powder. The mixing of the two phases of BSCCO, the 2212 and 2223 (11), or the addition of silver powder to the BSCCO powder before sintering. Those methods have had both desirable and undesirable results on the critical current and its behavior in a magnetic field.

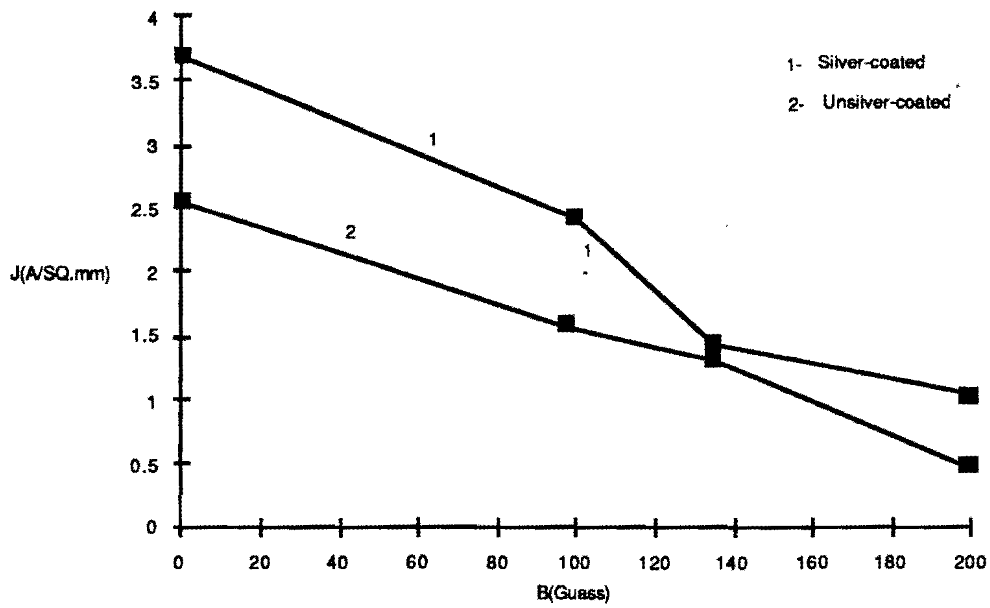

Figure 3. Critical Current density vs. Magnetic field for silver-coated and uncoated rods.

Here, we demonstrate for the first time, that the critical current characteristics of an HTSC material can be significantly improved by the application of a thin surface layer of silver which does not significantly add to the thermal conductivity of the rod. In addition, the above results suggest that even in granular HTSC material, the bulk of the current is carried near the surface.

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