High performance silver ohmic contacts to $YBa_2Cu_3O_{6+x}$ superconductors

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(Received 2 November 1987; accepted for publication 16 November 1987)

Silver-$YBa_2Cu_3O_{6+x}$ superconductor ohmic contacts with specific contact resistance on the order of 10^{-8} Ω cm^2 have been demonstrated. Alloying the contacts in O_2 at 500 °C enhances the contact conductivity by two orders of magnitude.

The recent discovery of superconductivity above 90 K in the Y-Ba-Cu-O system[1] has created a great deal of interest in the development of an even better compound and the practical applications of the already confirmed stable $YBa_2Cu_3O_{6+x}$ high-temperature superconductor (HTSC). Applications for the HTSC compounds and related materials[2-4] such as electronics interconnects, power transmission lines, Josephson and other devices, in addition to fundamental physics and chemistry studies, require (a) fabricating the compounds in forms and patterns that are suitable for each individual application, (b) improving the superconductivity critical current density, and (c) understanding and engineering the interface between HTSC and other materials. In this work we study the metal-HTSC interface and demonstrate a method of obtaining high performance silver-HTSC ohmic contacts.

Ohmic contacts between normal metals and HTSC materials are needed for most applications of the $YBa_2Cu_3O_{6+x}$ superconductor. In order to keep the stoichiometry of the HTSC and the conducting properties of the normal metal at the interface, the chemical reactions and interdiffusion of elements between the ceramic HTSC and the contacting metals must be well controlled or eliminated. These restrictions make the choice of contacting metals relatively limited.

Among many metals that we have investigated, silver demonstrates the best contact conductivity. Shown in Fig. 1 is the two-point resistance measured between two as-deposited silver contact dots, each of which is 3 mm in diameter, on an $YBa_2Cu_3O_{6+x}$ pellet. The two-point resistance is measured by passing a given current, up to 400 mA, through these two contacts with a pair of wires soldered to the silver contacts, and then measuring the voltage drop across these two contacts using another pair of wires. By doing this measurement, the ratio of measured voltage to the current gives the summation of the contact resistance for these two contacts and the bulk resistance seen by these two contacts. When the temperature is lowered below that for the zero resistance state of the superconductor, the two-point resistance is equal to two times the contact resistance for each contact. The $YBa_2Cu_3O_{6+x}$ pellets are prepared by (a) burning the premixed Y_2O_3, $BaCO_3$, and CuO powder corresponding to $YBa_2Cu_3O_y$ in air at 950 °C for 12 h, (b) grinding the burned HTSC and pressing the powder into 1.25-cm-diam pellets at room temperature up to 20 000 lbs, and (c) sintering the pellets in oxygen at 950 °C for 6 h.

Silver, which is 20 μm thick, is deposited onto the HTSC pellets through shadow masks by a thermal evaporator. The deposition process is controlled so that the HTSC surface is not overheated. The ohmic contact formed by the as-deposited silver film on a HTSC pellet has a two-point resistance that decreases with decreasing temperature as shown in Fig. 1. This is different from most of the ohmic contacts formed by metals that react with the HTSC. In those cases, the two-point resistance can even increase with decreasing tempera-

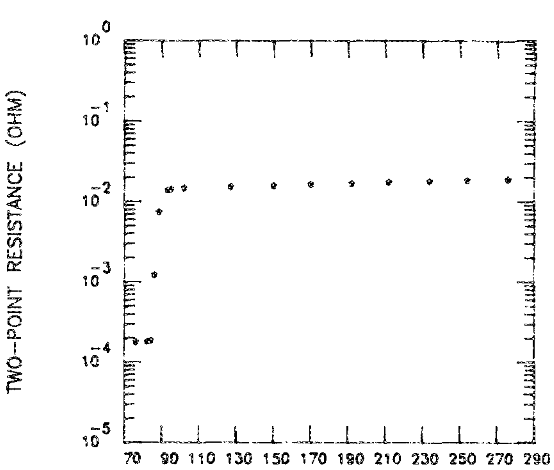

FIG. 1. Two-point resistance for as-deposited silver contacts to an $YBa_2Cu_3O_{6+x}$ superconductor. The contacts are 3 mm in diameter.

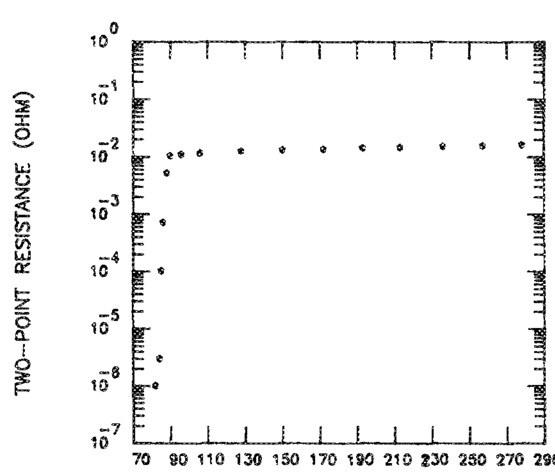

FIG. 2. Two-point resistance for silver contacts to an $YBa_2Cu_3O_{6+x}$ superconductor after alloying at 500 °C in O_2 for 5 h. The contacts are 3 mm in diameter.

ture.[5] When the temperature decreases below the superconductivity transition temperature the silver-HTSC two-point resistance decreases sharply and reaches $1.8\times10^{-4}\ \Omega$ at 77 K. For two contacts of 3 mm in diameter, this represents a specific contact resistance, i.e., the product of contact resistance with the contacting area, of $6\times10^{-6}\ \Omega\ cm^2$. After the silver-$YBa_2Cu_3O_{6+x}$ contact is heat treated at 500 °C for up to 5 h in an O_2 environment, the contact resistance decreases drastically by more than two orders of magnitude and demonstrates an excellent ohmic contact with the specific contact resistance equal to $4\times10^{-8}\ \Omega\ cm^2$. The two-point resistance for the heat-treated contacts is shown in Fig. 2. We believe this is the best reported metal-ohmic contact to the $YBa_2Cu_3O_{6+x}$ HTSC. Detailed investigation of the interfacial properties of the silver ohmic contact and further optimization of this contacting process are being conducted and will be published shortly.

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