

COMPOSITE SUPERCONDUCTING WIRES OBTAINED BY HIGH-RATE TINNING IN
MOLTEN Bi-Pb-Sr-Ca-Cu-O SYSTEM

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In the given communication we report on the principle possibility of the preparation of high- T_c superconducting long composite wires by short-time tinning of the metal wires in a molten Bi-Pb-Sr-Ca-Cu-O compound. As far as we know the application of this method to the high- T_c materials is tested for the first time.

The initial materials used for this experiment were ceramic samples with nominal composition $\text{Bi}_{1.5}\text{Pb}_{0.5}\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_x$ and $T_c = 80$ K (fig.1, curve 1) prepared by the ordinary solid-state reaction, and industrial copper wires from 100 to 400 μm in diameter d and from 0.5 to 1 m long. The continuous moving wires were let through a small molten zone (~ 100 mm³). The Bi-based high- T_c ceramics in a molten state is a viscous liquid and it has a strongly pronounced ability to spread on metal wire surfaces. The maximum draw rate of the Cu-wire, at which a dense covering was still possible, corresponds to the time of direct contact of wire surfaces and liquid ceramics for less than 0.1 s. A high-rate draw of the wire permits to decrease essentially the reaction of the oxide melt and Cu-wire. The realisation of the given method by simple technical means allowed to make the cylindrical composite wires, consisting of the copper core in a dense covering with uniform thickness of about $h \approx 5\text{--}50$ μm . Composite wires with $h \approx 10$ μm ($h/d \approx 0.1$) sustained bending on a 15 mm radius frame without flex cracking.

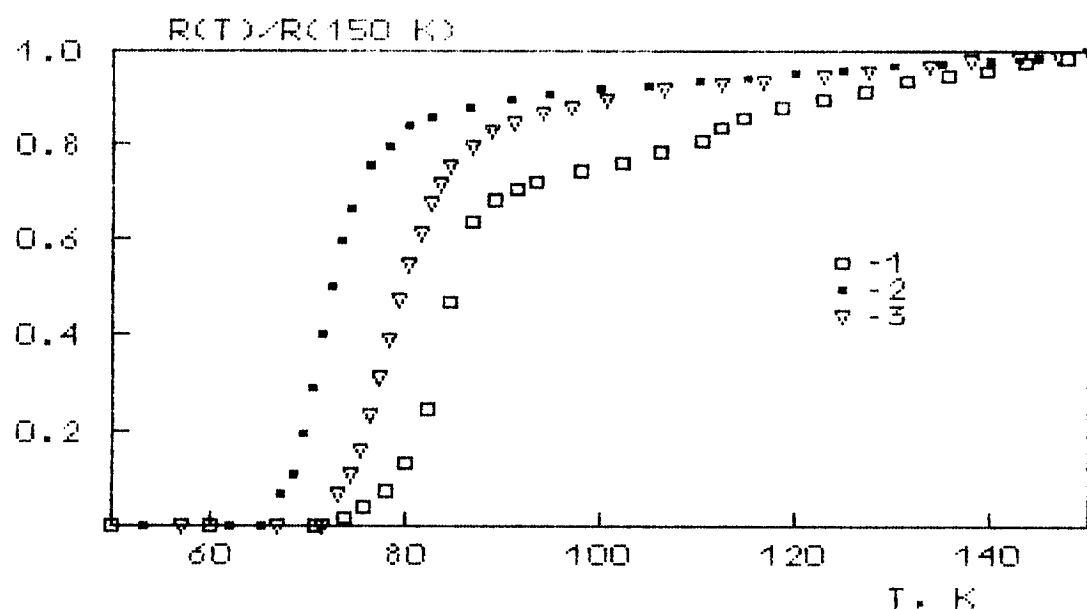


Figure 1

The microstructure and electrical resistivity R of the covering depend in a complicated manner on the covering process parameters. For example, the covering obtained at the draw rate of about 100 mm/s has a strongly marked axial texture consisting of thin plate-like crystals (the axis of the texture is parallel to the wire axis). As-obtained covering has no superconductivity properties. To restore the superconductivity the pieces of composite wires about 5 cm long were subjected to heat treatment at 800°C in air. Figure 1 shows the temperature dependence of the resistivities of the composite wires annealed for 20 (curve 1) and 41 min (curve 2). The electrical resistivity R was measured by a standard dc four-probe method with silver paste contacts using a constant current of 10 μ A. According to the resistivity curves the superconductivity transitions started at $T_{co} \approx 90-95$ K and ended at $T_{ce} \approx 68-71$ K. These values practically coincided with the values of critical resistivity points obtained on the initial multiphase ceramic bar (curve 1).

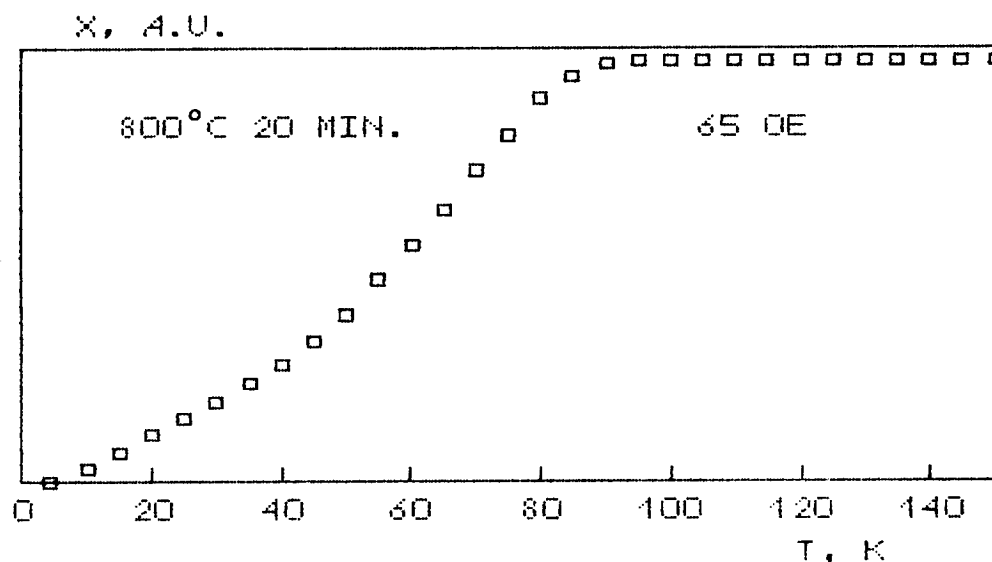


Figure 2

The direct evidence of composite wires superconductivity followed from their magnetic properties. Figure 2 shows the typical curve of susceptibility vs temperature for composite wires annealed at 800°C for 20 min. These measurements were performed using a SQUID magnetometer. The χ - T curve, similar to $R(T)$, has only one bend at 90 K. It is supposed that annealing at 800°C results in the predominant formation of only one superconductive ($T_c \approx 80$ K) phase. This concords with the data on the bulk Bi-Pb-Sr-Ca-Cu-O glass-ceramics, produced by the liquid quenching method and subsequently annealed at 750-800°C. Recently, as a result of improving the annealing conditions, we succeeded in preparation of composite wires with the higher zero-resistance temperature.

In summary, long high- T_c composite wires were prepared by high-rate draw of flexible bare conductor through molten Bi-based metal-oxide system.