PREPARATION AND PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTORS IN Bi,Pb-Sr-Ca-Cu-O AND Y-Ba-Cu-O SYSTEMS

By

ZOLTAN Z. KISH, *Ph.D*.

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The discovery of ceramic High-temperature (High-T_c) superconductors has revolutionized the field of superconductivity [1]. An extensive research effort has been undertaken to synthesize, characterize, and develop applications for these new materials, particularly in the form of films. For practical applications, such as electronic devices, magnetic shields or electronic tapes, the establishment of film preparation techniques is indispensable. Conventional film deposition techniques use high vacuum equipment such as magnetron sputtering [2] or laser beam evaporation [3]. However, for practical application, the fabrication method should be simple, speedy and inexpensive. Therefore, in this work, the simple and inexpensive chemical processes were used for the High-T_c superconducting film preparation, such as spray deposition [4,5], dipping [6], and the screen-printing [7] techniques.

The goal of this work is synthesizing, films preparation, and investigating properties of superconducting phases in the Bi,Pb-Sr-Ca-Cu-O and Y-Ba-Cu-O systems.

In the spray pyrolysis technique, the appropriate amounts of the corresponding metal nitrates were dissolved into pure water, which contained nitric acid. The corresponding solution was sprayed on the substrate, which was kept at 810 - 830 K on the hot plate. The careful controlled substrate temperature and the flow rate of the solution were important factors contributing to the good quality of the films. The deposition of the High-T_c superconducting films were repeated between once and ten times in order to control the thickness of the films [8-10]

On the other hand, in the dip-coating (painting) and screen printing techniques, the High-T_c superconducting films were prepared by using a slurry that consisted of the superfine powders of the corresponding superconducting phases and the different organic solvents [8-10].

The formation of the High-T_c superconducting phase mainly depended on the heat treatment temperature, the rate of the increasing and decreasing temperature, the time of the annealing, etc. The experiences show that the optimum composition of the investigated materials are $Bi_{2-X}Pb_XSr_2Ca_3Cu_4O_{12+Y}$ of the system Bi,Pb-Sr-Ca-Cu-O and $YBa_2Cu_3O_{7-x}$ of the system Y-Ba-Cu-O. The High-Tc superconducting phases of $Bi_{2-x}Pb_xSr_2Ca_3Cu_4O_{12+Y}$ are mainly formed at 1100-1115 K and of $YBa_2Cu_3O_{7-X}$ at 1190-1205 K in air. In addition, the phase of $YBa_2Cu_3O_{7-X}$ was annealed at 670 - 685 K in the oxygen atmosphere.

The films were deposited onto different substrate such as Al_2O_3, MgO, Si, BN, etc. However, the superconducting phases rapidly reacted with the materials of the substrate during annealing at temperatures above 1050 K. Therefore, the substances Cu, Ag, CuO and different ceramic oxides have been used as barrier layers. The materials of the barrier layers were selected to minimize the difference of the crystal structure and reaction between spattering materials and superconducting phases. When the corresponding barrier layer was interposed between the superconducting oxide films and the underlying substrate, the prepared films have exhibited much better superconductivity behavior. Therefore, preliminary barrier layers were deposited onto substrate. Then the High-T_c superconducting films were formed onto this substrate with barrier layers.

Electrical measurements were carried out using a standard four-probe technique in low-temperature cryostat. The best samples of the system Bi,Pb-Sr-Ca-Cu-O showed an onset of the superconducting transition at 170 K and the zero resistance was achieved at 116.5 K. The film of $YBa_2Cu_3O_{7-X}$ also showed the superconductor behavior and the zero resistance was achieved at 92 K. The critical density of current was about 10^3 A/cm^2 for both phases.

The crystal structure of the superfine powders and superconducting films were analyzed by X-ray diffractometer. The superconducting films mainly exhibited C-axis orientation.

In summary, the of the High-T_c superconducting film deposition has been optimized using the corresponding barrier layers, pre-annealing and crystallization heat treatment conditions in order to minimize the film decomposition and to achieve the best film compactness and composition. In addition, these requirements appear necessary for optimization of the films superconducting properties. The High-T_c superconducting properties of the films were reproducible, and the samples were stable under the test. On the other hand, the superconducting films with the different thickness (1-25 μm) on surfaces of the different shapes and sizes, as well as easy control of the film composition can be obtained by these techniques.

The spray pyrolysis, the dip-coating (painting), and the screen printing techniques, described in this paper, appeared very promising for the deposition of the different compositions of the High-T_c superconducting films. These techniques have special advantages, low cost and simple preparation processes and therefore, they can be used for the fabrication of High-T_c superconducting films.

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