UNIVERSITI TEKNOLOGI MARA

THE EFFECT OF THERMO-MECHANICAL TREATMENTS AND EXTERNAL MAGNETIC FIELDS ON THE TRANSPORT CRITICAL CURRENT OF Cr, Mo AND In SUBSTITUTED Tl-1212 DIP-COATED TAPES

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Master

MAC 2007

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Thesis Title	The Effect Of Thermo-Mechanical Treatments And External Magnetic Fields On The Transport Critical Current Of Cr, Mo And In Substituted Tl-1212 Dip-Coated Tapes.

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ABSTRACT

In this work, Tl-1212/Ag dip-coated (DC) tapes were fabricated using Tl1212 superconducting powders prepared from different nominal compositions and subjected to different combinations of thermal and mechanical treatments. The effects of the thermo-mechanical treatment on the transport critical current density (J_c) in zero field and low magnetic fields were investigated. The superconducting powder prepared with nominal compositions $Tl_{0.9}Cr_{0.1}Sr_2Ca_{0.9}Pr_{0.1}Cu_2O_7$ (Cr-tapes), $Tl_{0.9}Bi_{0.1}Sr_{1.9}Mo_{0.1}Ca_{0.9}Y_{0.1}Cu_2O_7$ (Mo-tapes) and $Tl_{0.9}Bi_{0.1}Sr_{1.9}In_{0.1}Ca_{0.9}Y_{0.1}Cu_2O_7$ (In-tapes) which were synthesized by conventional solid state method. In the DC technique, silver strips were dipped into slurry made from mixture of superconducting powder, solvent, binder and dispersant. Some of the resulting tapes were subjected to mechanical rolling to investigate the effect of rolling on 1212 phase formation, critical temperature, T_c and critical current density (J_c) of the tapes. For Cr-tapes, reannealing at > 870 °C caused higher Tl, evaporation resulted in lower 1212 volume % and produced partial melted microstructure. By considering the volume % of 1212, T_c and J_c, annealing at 870 °C was the best heat treatment to produce reasonable J_c. The higher magnitude of J_c is attributed to the enhancement of grains contact within the core of the tapes as observed form its microstructure. For Mo-tapes, it was observed that different thermo-mechanical treatment on the tapes resulted in different values of J_c. J_c enhancement was observed for tapes annealed at ≥ 870° C in combination with mechanical rolling. The results show that re-annealing at ≥ 870° C improves 1212 phase formation and J_c for Mo-tapes. However annealing at lower temperature caused the presence of higher amount $SrCO_3$. The best performance in external magnetic field was observed for rolled tapes annealed at 910° C. For In-tapes, annealing at higher temperature improves 1212 phase and reduced $SrCO_3$ content. The presence of $SrCO_3$ may be the other reason for lower T_c and J_c values. The performance of J_c in magnetic field was limited by weak links. However, the development of strong links was much easier for In-tapes compared to Mo-tapes. In general, mechanical rolling promotes grains connectivity and improves intergranular connectivity. It was observed that appropriate annealing temperature in combination with rolling improves 1212 phase, T_c and J_c. However the presences of impurities limit the superconducting properties of the dip-coated tapes. J_c observed in this work are generally comparable to the values of Tl-1212 tapes using powder-in-tube (PIT) method.

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CHAPTER 1

INTRODUCTION

The phenomenon of superconductivity has always been very exciting and has been explored both for fundamental and scientific interest and for possible technical applications. Superconductors have many remarkable electromagnetic properties, and most applications take advantages of such properties. A superconductor exhibits no electric resistance to dc current, no heating and no losses. For example, once a current is produced in a superconducting ring maintained at a sufficiently low temperature, it will persist with no measurable decay. In addition to the property of zero resistance, a superconductor can expel applied magnetic fields so that the field is always zero everywhere inside the superconductor. The material is able to expel or exclude external magnetic field from its interior. The most interesting consequence of this behavior is the ability to levitate permanent magnet over a superconducting surface.

In conventional superconductors, superconductivity is caused by a force of attraction between electron pairs arising from the exchange of phonons. This mechanism of conventional superconductors based on electron-phonon interaction was successfully explained by the BCS theory. There also exists a class of material, known as unconventional superconductors, that exhibit superconductivity but whose physical properties contradict the BCS theory. In particular, high-temperature superconductors superconduct at temperatures much higher than should be possible according to the BCS theory. High temperature superconductors (HTSC) consist of several cooper-oxide based system which are Y (RE-Earth), Bi, Tl and Hg with critical temperature above 77 K. The most well known of high temperature superconductor is $YBa_2Cu_3O_{7-\delta}$ (Y123) with transition temperature higher than 92K (Wu et al. 1987). The high-temperature