

COMPARATIVE STUDY ON Tl1212/AG DIP-COATED TAPES FABRICATED USING SOLID-STATE AND COPRECIPITATION DERIVED POWDERS

F. MD. SALLEH, A. K. YAHYA

Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

Z. AWANG

Microwave Technology Center, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

M. H. JUMALI

School of Applied Physics, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Abstract Ag clad dip-coated superconductor tapes were fabricated from Tl-1212 superconducting powders of $Tl_{0.8}Bi_{0.2}Sr_2Ca_{0.8}Y_{0.2}Cu_2O_7$ starting composition derived via two different methods: the conventional solid-state (SS) and coprecipitation (CP) methods. The effects of using superconducting powders derived from SS and CP methods on phase formation, microstructure and critical current density were investigated for tapes annealed at 850°C for 60 minutes in flowing O_2 . XRD analysis of the tapes oxide cores indicated a higher volume percentage of 1212 phase for the SS tape compared to the CP tape. However, the oxide J_c of the CP tape ($4670 A/cm^2$) was higher than the SS tape ($557 A/cm^2$). The SEM micrograph of the CP tape's oxide core revealed melted-like fused grains, a factor that was associated with high J_c value of the tape, in contrast to the SS tape's core that displayed cracks and porous microstructure.

KEYWORDS: Superconductor tapes, transport critical current density, dip-coating method

Introduction

Amongst Tl-based superconductor tapes, much work have been done on single Tl-O layered Tl1223 for applications in superconducting motors, transformers, transmission lines and magnets (Goyal *et al.*, 1995; Selvamanickam *et al.*, 1996). Besides Tl1223, single Tl-O layered Tl1212 has been suggested to show better in-field behavior compared to multiple Tl-O layers system (Jergel *et al.*, 1996). Tl1212 is also expected to produce higher transport critical current density (J_c) and better performance in magnetic fields compared to Tl1223 due to reduced anisotropy through its stronger interlayer coupling and less severe thermally activated flux motion (Lao *et al.*, 2000). Some works have been reported on Tl1212/Ag tapes using powder-in-tube (PIT) method (Hamid *et al.*, (2001) but no report was found for Tl1212 using dip-coating (DC) which is a faster and simpler method of tape fabrication. A key factor in processing Tl1212 tapes to achieve high J_c is to optimize not only the processing details of the tapes but also the quality of the superconductor powders used. In this paper, we report on Tl1212/Ag dip-coating tapes fabrication using powders prepared by solid-state (SS) and co precipitation (CP) methods. Results of powder X-ray diffraction (XRD) and scanning electron microscope (SEM) investigations on the tapes are presented and analyzed.

Correspondence: Faizah Md. Salleh, Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

Material and Methods

Superconducting pellet of $Tl_{0.8}Bi_{0.2}Sr_2Ca_{0.8}Y_{0.2}Cu_2O_7$ superconductor was initially prepared via two different synthesis routes. The bulk SS sample was prepared by a two-step solid-state reaction, as described in previous work (Yahya *et al.*, 2004). In the co precipitation route, similar synthesis process as described as in Ref. (Md. Salleh *et al.*, 2005) was used. A slurry solution was then prepared by mixing the superconductor powder with appropriate amounts of organic binder, dispersant and solvent (Sung *et al.*, 2000). Strips of silver substrate were dipped into the slurry and coated films of 0.25 – 0.40 mm in thickness were achieved and monitored. The coated silver strips were dried at 80°C for 2 days and separately wrapped using silver foil. Then the tapes were subjected to heat at 450°C in air for 3 days, after which they were deformed by cold rolling to 45% – 55% deformation in tapes thickness. The tapes were annealed in flowing O_2 at 850°C for 60 minutes.

Electrical resistance (dc) measurements for both tape samples were carried out using the standard four-point-probe method with silver paint contacts in a Janis model CCS 350ST cryostat in conjunction with a closed cycle refrigerator from CTI Cryogenics model 22. The phase characterization was done by powder XRD using Bruker D8 Advanced diffractometer with $Cu-K_{\alpha}$ source. Transport critical current densities (J_c) were measured in zero magnetic fields using standard four-point-probe method and evaluated using the electric field criterion of $1 \mu Vcm^{-1}$. SEM micrographs were recorded using JEOL JSM-6360LA analytical scanning electron microscope.

Results and Discussion

XRD patterns for both fabricated tapes are shown in Fig. 1. The XRD results indicate that both SS and CP tapes consist of major 1212 phase and minor 1201 phase. In addition, the CP tape was found to consist of $SrCO_3$ impurity. Table 1 lists thermo-mechanical history, zero-resistance critical temperature ($T_{c\ zero}$), 1212:1201: $SrCO_3$ phase volume ratio and transport J_c at 40 K obtained for both SS and CP tapes prepared in this work. The samples exhibit metallic behavior in its normal state and $T_{c\ zero}$ of 71 K and 82 K for the SS and CP tapes, respectively.

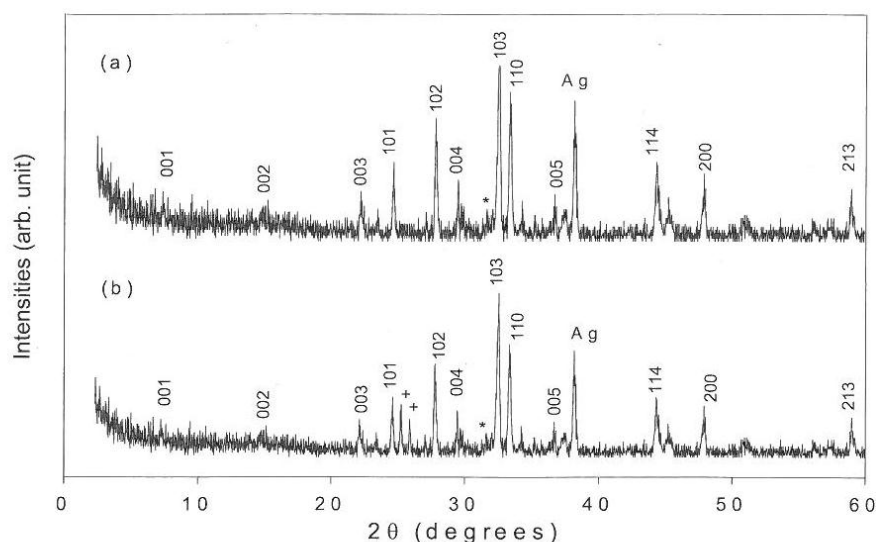


Figure 1. Powder X-ray diffraction pattern for tape samples (a) SS; (b) CP; (*) and (+) indicate peaks due to 1201 phase and $SrCO_3$ impurities, respectively

Table 1. Tape sample thermo mechanical history, zero-resistance critical temperature ($T_{c \text{ zero}}$), 1212:1201:SrCO₃ phase vol.% and transport critical current density (J_c) at 40 K of the dip-coated SS and CP tapes

Tape sample	Thermo-mechanical treatment	$T_{c \text{ zero}}$ (K)	1212:1201: SrCO ₃ (vol.%)	J_c at 40 K (A/cm ²)
SS	450°C / 72 h + 850°C / 60 min	71	88 : 12 : 0	557
CP	450°C / 72 h + 850°C / 60 min	82	69 : 9 : 22	4670

Figure 2 shows SEM micrographs of fractured surface of the bulk pellets and of superconducting oxide core of the tape samples. The micrograph of CP bulk (Fig. 2c) revealed elongated plate-like grains, which is remarkably different from the micrograph of SS bulk (Fig. 2a) that revealed slightly rounded grains. Interestingly, the micrograph of CP tape's core (Fig. 2d) displayed partially melted and fused grains in contrast to micrograph of SS tape's core (Fig. 2b) that revealed porous microstructure. No particular texturing was observed from the SEM micrographs of both the tapes core.

In this work, higher J_c has been obtained for CP tape (4670 A/cm²) than that for SS tape (557 A/cm²). In view of the fact that the 1212 volume fraction for CP tape was only 69%, it is possible that J_c can be further increased by increasing the 1212 volume fraction. Since the volume fraction of 1212-phase in CP tape was lower than SS tape (Table 1), it is suggested that the highest magnitude of J_c for CP tape may due to the volume fraction of 1212-phase but instead it maybe due to other reason such as the microstructure of the tapes core.

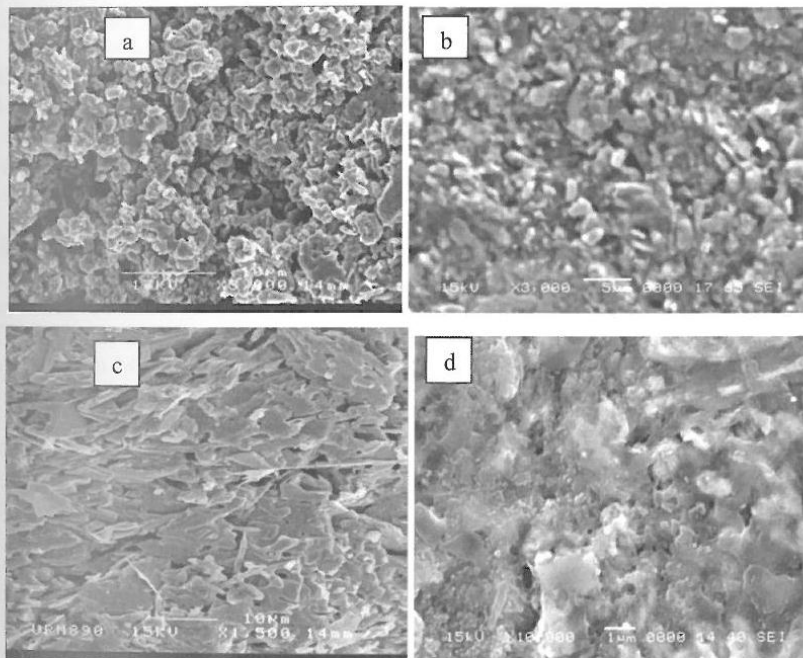


Figure 2. Microstructures of bulk and tapes samples: (a) SS bulk; (b) SS tape; (c) CP bulk; (d) CP tape

SEM micrographs showed less porous oxide core for CP tape (Fig. 2d) as compared to that of SS tape (Fig. 2b). It is known that porous microstructure results in poor continuity of supercurrent path and causes reduction in sample J_c (Jeong and Sohn, 1998). Although the use of coprecipitation did not promote any texture development in the tape (Fig. 2d), it is suggested that improved connectivity between grains was achieved due to the partially melted microstructure. Previous study on Tl1212/Ag tapes fabricated via the PIT method (Hamid and Abd. Shukor, 2001) also showed higher J_c value for tapes with partially melted microstructure. As such, it is suggested that the higher J_c observed for CP tape in the present study is due to the increase in grains connectivity as a result of partial melting.

Conclusion

Tl_{0.8}Bi_{0.2}Sr₂Ca_{0.8}Y_{0.2}Cu₂O₇ tapes employing solid-state and coprecipitation derived oxide powder were fabricated using dip-coating technique on silver substrate. The tape fabricated using coprecipitation derived oxide powder has superior transport J_c than the tape prepared by solid state derived powder. The enhanced J_c of the CP tape was attributed to the highly fused grains as revealed by SEM micrograph.

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