Tl-based Films Grown on Silver Tape Substrates

C. Falcony, M. Jergel, and A. Morales
Depto. de Física and PMCATA, CINVESTAV-IPN, Apdo. Postal 14-740, México D.F., México

M. García,
Instituto de Investigación en Materiales, UNAM, Apdo. Postal 70-360, México D.F., México

R.T. Hernández and A. De Ita
Depto. de Materiales, UAM-Azcapotzalco, C.P. 02200, México D.F., México

J.G. Cabañas-Moreno
Depto. de Ingeniería Metalúrgica, IPN, Apdo. Postal 75-373, México D.F., México

J. Palacios G.
ESFM del IPN, UPALM, 07738, Apdo. Postal 75-373, México D.F., México

R. Martínez
CICATA-IPN, Legaria No. 694, C.P. 11500, México D.F., México

Abstract - **The Tl-based superconductors belong to potential candidates for high-current and high-field applications. It is therefore of importance to prepare them in the shape of tapes or wires. It seems, that silver tape is a very convenient material having suitable mechanical properties as well as chemical compatibility with superconducting films deposited and grown on top of them. In our case, Tl-based films were grown using a two-step procedure. First, the Ba-Ca-Cu precursors were deposited on a commercial silver tape from an aerosol, and then the precursors were thallinated in a closed crucible with a source of Tl-oxide in the form of crude pellet. Results are reported on superconducting samples consisting so far of 2212, 2223 and 1223 phase mixture. SEM observations revealed growing of plate-like grains. Metalurgical processing of silver tape is underway as to obtain cubic texturized substrate which should help to improve transport properties of the grown films.**

I. Introduction

The Tl-based superconductors are of considerable interest for high-current, high-field applications. Their irreversibility lines, specially that of $TlBa_2Ca_2Cu_3O_x$ (Tl-1223) compound, lie rather close to the line of Y-based (Y-123) superconductor and they eventually may work in external magnetic field at temperatures up to 77K. The weak-link connections among superconducting grains, influencing the critical current density of superconductor, may be improved either by a crystal lattice alignment, or by improving the grain connectivity [1]. From this point of view, the open preparation approach, i.e. the deposition of films on suitable substrates, is superior to the so called PIT (powder-in-tube) method. The Ag-tape is often used for this purpose and spray pyrolysis is used as a film deposition method [2],[3],[4],[5].

It was found and proved that bi-axial substrate texturing helps to grow aligned and texturized films, increasing thus substantially the transport critical current density J_c values [3], [5].

Two Tl-based compound systems were successfully developed, the Tl-Ba-Ca-Cu-O [2],[3] and the Tl-Ba-Sr-Ca-Cu-O [4],[5]. It is a purpose of this paper to show results of our similar investigation.

II. Experimental

A commercial PEÑOLES silver melted and then laminated or GOODFELLOW Ag-foil, cold rolled, 240 μm thick, with 99.9% purity has been used as a substrate. Prior to the precursor film deposition the Ag-foil was annealed at 800°C/2h and characterized by X-ray diffraction and pole figure measurement. The size of laboratory samples was (10 to 25) mm x 5 mm. Superconducting samples were prepared in two steps, i.e. the precursor deposition and their thallination.

The Ba-Ca-Cu-O (BCCO) precursor deposition was performed by spray pyrolysis from an aerosol nebulized ultrasonically. The thickness of deposited BCCO films was of the order of 1μm. Precursor samples were then placed together with a crude $Tl_xBa_2Ca_2Cu_3O_y$ pellet in a closed alumina crucible. Thallination was performed in 1-zone reaction chamber at 860°C to 880°C for 30 min to 90 min in flowing oxygen. After the thallination, samples were furnace-cooled down to room temperature. Superconducting Tl-Ba-Ca-Cu-O (TBCCO) samples were characterized by X-ray diffraction, R(T) measurements and by EDAX analysis. SEM morphology observations and pole figure measurements were performed. Results of these investigations are reported.

III. Results and Discussion

The X-ray diffraction patterns of GOODFELLOW Ag-tape used for precursor deposition are shown in Fig. 1. A

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pronounced texture and orientation perpendicular to the substrate surface may be seen from the diagram. We found however, that this texture depends strongly on the thickness reduction of the tape during the rolling process. Results of {100} pole figure measurements of the Ag-tape with 97% reduction used to prepare sample AC-80 are demonstrated in Fig. 2. A strong grain orientation found by X-ray diffraction has been confirmed also here: as a pronounced pole in the center of the figure is observed. There are smaller poles corresponding to other crystalline orientations. An additional {110} pole figure measurement, Fig.3, showed a strong bi-axial texturing of the tape with the {110} along the rolling direction.

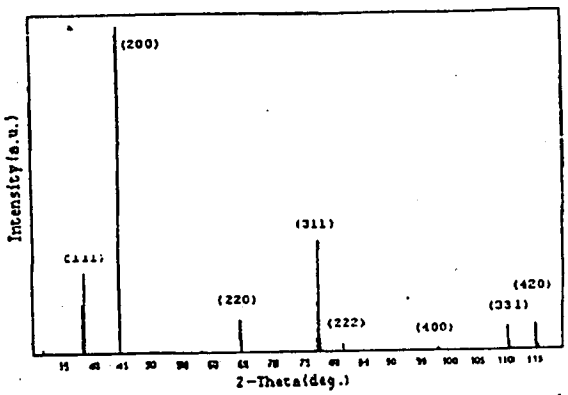

Fig.1. X-ray diffraction patterns of Goodfellow Ag-foil used as a substrate.

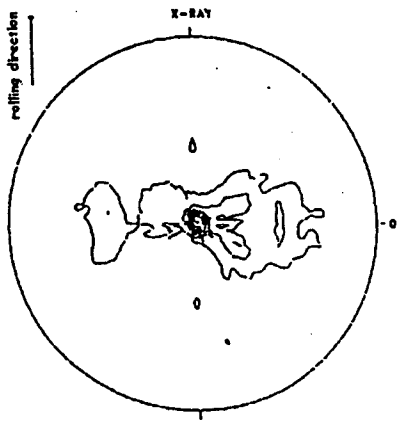

Fig.2. The {100} pole figure of Ag-tape used to prepare sample AC-80.

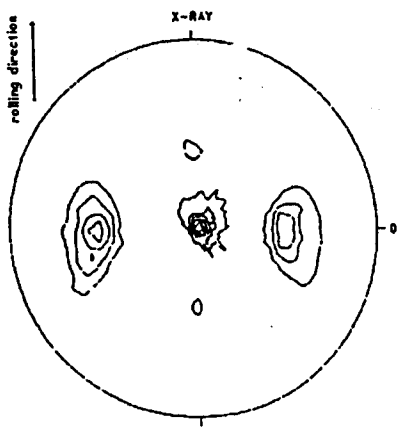

Fig.3. {110} pole figure of Ag-tape used to prepare sample AC-80.

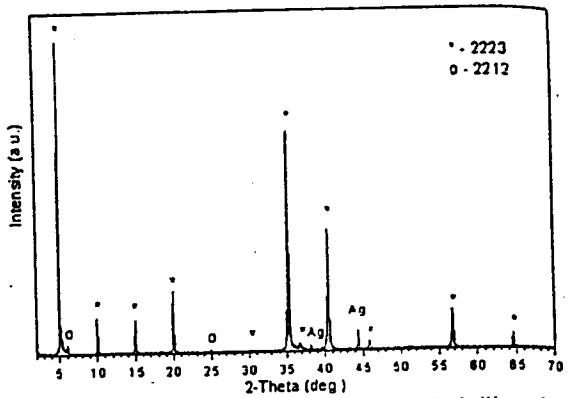

Fig.4. X-ray diffraction patterns of the sample AC-80, thallinated together with AC-81 at 870°C/60min.

The X-ray diffraction patterns of superconducting sample AC-80 thallinated together with AC-81 at 870°C/30 min are shown in Fig.4. In this case, nearly pure 2223 phase has been grown with only traces of the 2212 phase and 1223 phase. The R(T) dependence of both mentioned samples, i.e. AC-80 and AC-81, is plotted in Fig. 5.

The {001} pole figure of the sample AC-80 is demonstrated in Fig. 6 with a strong central pole. In case of the {110} direction pole figure, Fig.7, a partial bi-axial texturing has also been observed with tetragonal geometry being characteristic for 2223 phase of the sample AC-80. The grain orientation was confirmed by SEM investigation which has shown plate-like grains on the surface of samples, Fig.8.

IV. Summary

A relatively good bi-axially textured Ag-tape has been developed by means of combination of metalurgical and thermal treatment. This type of tape has been used to prepare Tl-based films in two steps. Spray pyrolysis was used to deposit Ba-Ca-Cu-O precursors which were then thallinated in 1-zone reaction chamber.

The best Tl-based films show T_c>100 K. The morphology observations revealed plate-like grains on the sample surface.

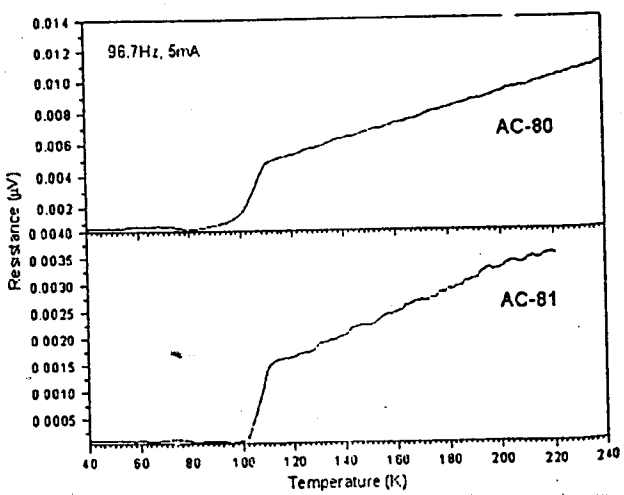

Fig.5. R(T) dependence of the samples AC-80 and AC-81.

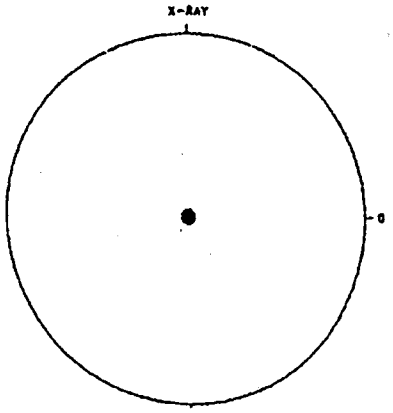

Fig.6. The {001} pole figure of the sample AC-80.

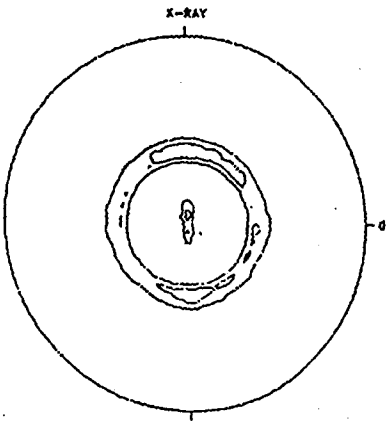

Fig.7. {110} pole figure of the sample AC-80.

X-ray diffraction patterns show strong *c*-axis orientation. Synthesized films consist so far of a mixture of 2212, 2223 and 1223 phases. Pole figure measurements of Tl-based samples show relatively good {001} <110> bi-axial texturing.

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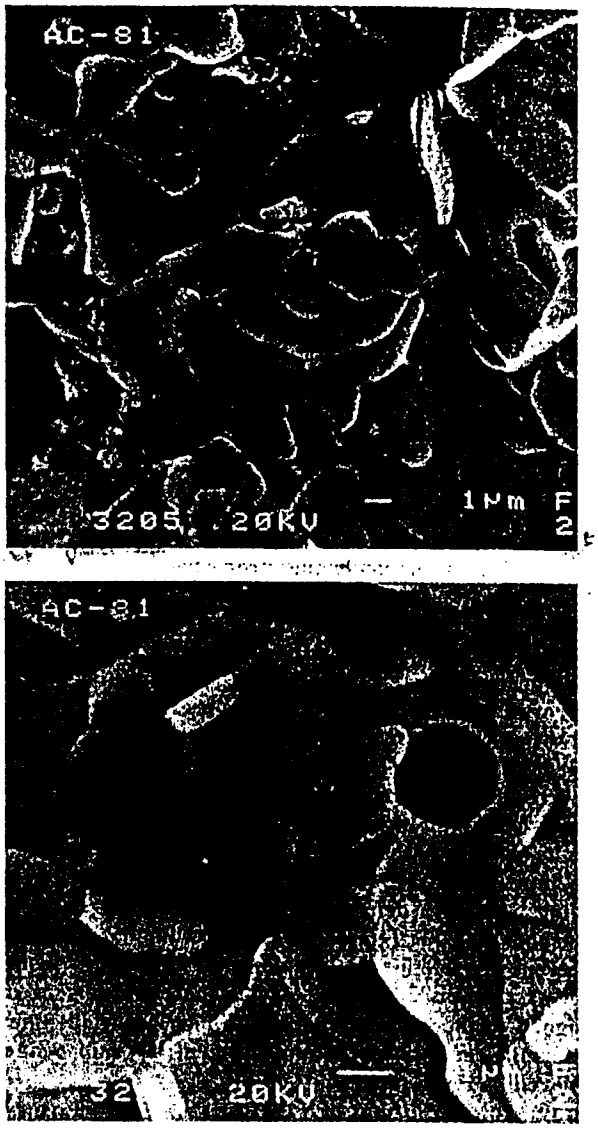

Fig.8. The surface of the sample AC-81 at 2000x and 4000x.

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