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CHANGES ON ELECTRICAL PROPERTIES OF AG/BSCCO PIT TAPES BY THE ADDITION OF DIFFERENT PROPORTIONS OF SILVER METAL POWDER

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ABSTRACT

Monofilamentary tapes (150 μm thickness) were prepared by swaging and rolling silver tubes containing the Bi:2212 ceramic (granulation below 20 μm) and the silver powder (grain size about 0.8 μm). The study has been made, among other samples, on tapes with nominal proportions of 0, 10 and 20wt% of silver. The samples were characterized by SEM, and by electrical measurements under varying applied magnetic field. The measurements of J_c showed that the addition of 10wt% silver powder enhances this property, doubling the obtained values at 60 K, while the 20wt% tape presented very low J_c. The tape with no silver content has a J_c as high as $2.2x10^5$ A/cm^2, at 4.2 K and zero applied magnetic field.

1. INTRODUCTION

According to A. Y. Ylyushechkin et al. [1], $Bi_2Sr_2CaCu_2O_x$ (hereafter Bi-2212) superconductor remains one of the best materials for industrial applications, such as magnets and cables, because of a high current carrying capability [2]. The superconducting tapes made by PIT [3] (Powder in Tube) method have been studied since 1989 and have been cited as the most successful and easily adaptable process to large scale fabrication [4].
The addition of Ag to Bi-based ceramic has been found to have a beneficial effect on the critical current density J_c associated to the flux pinning improvement [5].
In this work we present some experiments on monofilamentary tapes, in which 0, 10 and 20wt% silver powder was added to the Bi-2212 ceramic phase encapsulated in silver tube, characterizing a particular PIT process.

2. EXPERIMENTAL

In Fig. 1 is showed the x-ray diffraction pattern of the ceramic Bi-2212 single-phase powder made by the conventional route. This powder, obtained from pellets that were sintered at 842°C for 110 hours in air, was mixed with silver metallic powder (0.5-0.8 μm) in the two desired weight proportions. The silver tubes, with 5 mm OD and 3 mm ID, were filled with each mixed powders and sealed with copper wires at the ends to avoid leaking. Afterwards the rods were swaged and rolled until reaching 150 μm thickness and about 4 mm wide. In Fig. 2 is presented a diagram showing the process. These tapes were submitted to heat treatment in air, consisting of heating up to 890°C at a rate of 250°C/h, an isothermal at this temperature for 2 hours, cooling to 830°C at a rate of 4°C/h, an isothermal at 830°C for 5 hours, and rapid cooling to room temperature. The sintered material and the tapes were observed using SEM and submitted to the four-probe standard test for the critical temperature and current density characterization.

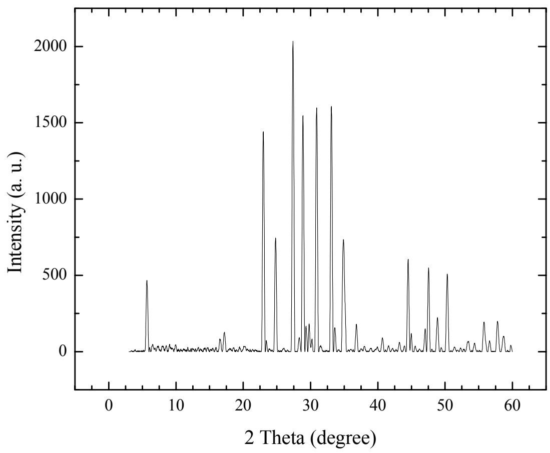

Figure 1 – Diffraction pattern of powder Bi:2212 inserted in the silver tube.

3. RESULTS AND DISCUSSION

In Fig. 3 a SEM micrograph shows the typical regularity of the longitudinal section of the tapes before applying the heat treatment.
The mapping micrograph showed in Fig. 4 presents the silver distribution inside the sintered ceramic bulk for the 10wt% silver proportion sample. In this micrograph one can observe, on the polished surface, that the metallic silver ag-

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gregates between the ceramic crystals. Although it is not possible to observe by this picture, the silver agglomerates have about the same dimensions of the ceramic grains, it means around 20 μm of average size.

The electrical measurements presented transition temperatures about the same for all the samples, showing lower range of the electrical resistivity as the Ag content increases. A typical resistivity curve observed for the tapes is shown in Fig. 5. In this case, the observed T_c onset was about 82 K, and in general was observed to vary in the range of 79 ± 3 K for all samples.

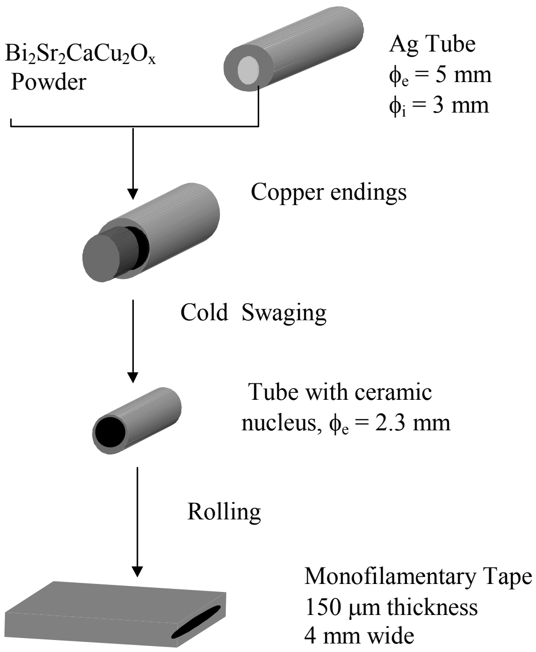

Figure 2 – The PIT process used to prepare the tapes.

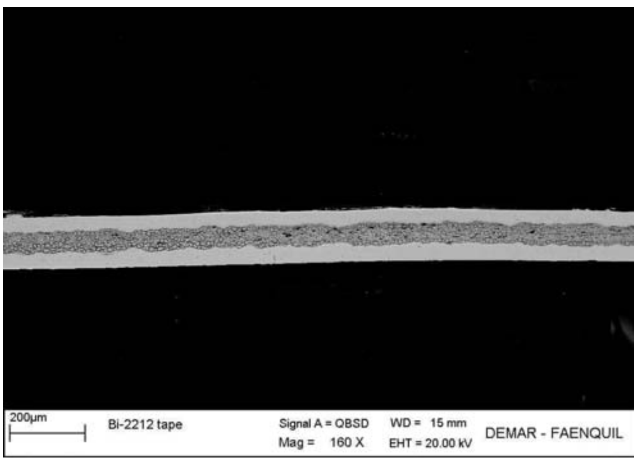

Figure 3 – Transversal section of Ag/BSCCO tape.

The critical current density J_c determined (1μV/cm criterion) at 4.2K, with no applied magnetic field, for the tape without silver addition was 2.2 x 10^5 A/cm^2. This same measurement made with applied field of 9 T presented critical current density of 6.3 x 10^3 A/cm^2. The J_c estimation made at 60 K, under zero applied magnetic field, showed distinct current limits for each silver content tape. The value observed for the 10wt% silver content sample was about 1-2x10^3 A/cm^2. Half of this value was found for the no silver content tape. The 20wt% silver content tape showed to have even lower J_c than the others. This fact may be justified by the excess of silver agglomerates which may behave more like non-superconducting barriers instead of local defects trapping the magnetic field (pinning centers). Actually, in experiments made in bulk composite ceramic with this same silver content [6], it was verified that the T_c of the high silver content samples are very sensible to the applied current. In Fig. 6, a diagram showing the J_c as a function of the silver content is presented.

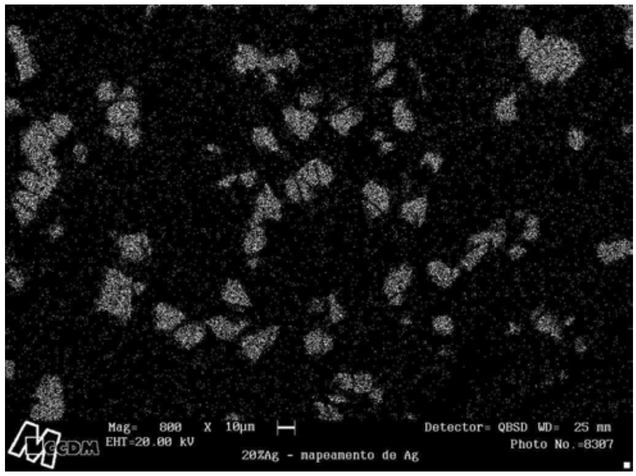

Figure 4 – Silver mapping on 10wt% Ag ceramic composite.

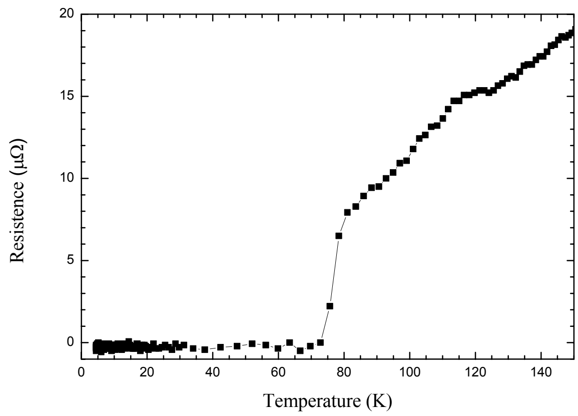

Figure 5 – Resistivity measurement on tape without silver.

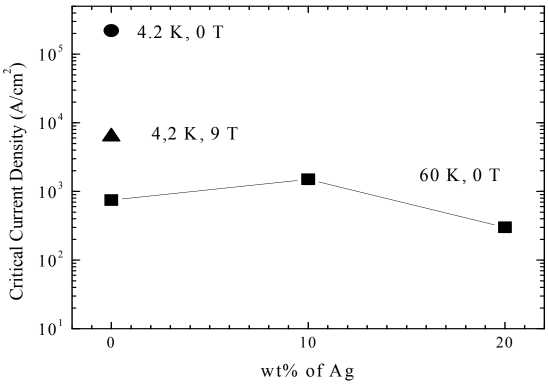

Figure 6 – Critical current density for tested samples.

4. CONCLUSIONS

Tapes made by a particular PIT process were fabricated using ceramic filling with 0, 10 and 20wt% silver content. All the tapes have shown good uniformity along the longitudinal and transversal directions. The tape with no silver content showed *to* have a J_c as high as 2.2 x 10^5 A/cm^2, at 4.2 K, zero applied magnetic field. The estimation of the critical current densities of the tapes at 60 K showed that the addition of 10wt% silver powder is very beneficent to this property, doubling the values of J_c comparing to the original no silver powder tapes estimated at and no applied field. The same was not found for the 20wt% tape, which presented very lower J_c at this temperature.

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