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Electrical and Magnetic Characterization of Hot-Extruded BSCCO Tape Samples (*).

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Summary. — Ag/BSCCO-2223 phase tapes were prepared with a new plastic deformation cycle. Starting from the hot extrusion of composite billets, hundreds of metres of tape 0.15×3 mm were obtained by drawing and rolling the extruded bars. The cross-section, monofilamentary with a central Ag insert, is quite regular along all the length. Samples from 30 cm to 100 cm in length were heat-treated at different temperatures between 830 °C and 480 °C in Ar + 10% O_2 atmosphere. Electrical-transport properties were tested at 77 K. J_c of 3000 A/cm^2 were usually achieved after first heat treatment. The superconducting properties were also tested by magnetic measurements using a vibrating sample magnetometer.

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1. – Introduction.

The hot-extrusion process seems to be the most promising technique to obtain long unit lengths of g/BSCCO superconducting wires and tapes, with good compaction of the powder [1]. It is possible, by means of such a technique, to obtain continuous lengths of ceramic superconductor considerably greater than what is possible using the powder-in-tube technique [2]. Furthermore, given the good level of compaction of the powder, it is possible to obtain tapes with good transport characteristics without having to resort to further processes of rolling or pressing and sintering. The use of the hot-extrusion thecnique has allowed EM-LMI to produce Ag-sheathed Bi-2223 tapes of over 1000 m in length. Straight samples of about 100 cm were then heat-treated and characterized by structural, electrical and magnetic measurements. Encouraging results were obtained in terms of critical current after

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the first heat treatment and preliminary results on pinning force and flux penetration are reported.

2. – Experimental.

Europa Metalli-LMI has developed a hot-extrusion process and therefore it is now possible to obtain, in a very reproducible way, starting from an Ag billet filled with superconducting powder, over 1000 m of Ag/BSCCO tape or wires in different dimensions. Quite a few preliminary tests were performed to set up both extrusion parameters and the subsequent drawing and rolling cycles. Such tests have enabled the production of wires in BSCCO-2212 and tapes in BSCCO-2223.

Figure 1 shows the metallographic cross-section of a BSCCO-2223 tape. This layout, showing the concentric superconducting ring with an inner Ag core configuration, was developed in collaboration with CISE (Milan). Numerous metallographic cross-sections carried out on approximately 100 m of tape did not show any variation in internal configuration and dimensions of the tape.

Straight samples of 100 cm in length of this type of tape were heat-treated at different temperatures between 835 °C and 840 °C in a controlled atmosphere ($Ar + 10\% O_2$).

Structural analysis on reacted samples was performed using a scanning electron microscope. Figure 2 shows the micrography carried out by the SEM where it is possible to observe the typical flat configuration of the BSCCO grains. Transport electrical properties were tested at nitrogen temperature in zero field and in a magnetic field of up to 2000 Gauss.

Magnetic characterization on short samples was performed with the use of a vibrating sample magnetometer by taking hysteresis loops up to 1 T at different temperatures (15–100 K), the field being applied perpendicularly to the tape. Critical current densities have also been evaluated using Bean's critical-state model:

$$J_c = 15\,\Delta M/r\,,$$

where ΔM is the difference in magnetization measured for increasing and decreasing field, and r is the average BSCCO grain size.

Fig. 1. – Metallographic cross-section of a monofilamentary BSCCO-2223 tape.

Fig. 2. – SEM micrograph of BSCCO grains.

The time relation of the magnetization (M_{ZFC}) was studied by cooling the sample down to 20 K and then applying a field of 500 G, kept constant during the measurement.

3. – Results.

The values of the critical current densities measured on 100 cm long samples, after the first heat treatment, were typically in the range of $3000\,A/cm^2$ ($1\,\mu V\,cm^{-1}$ criterium).

The decay of the normalized critical current as a function of the magnetic field at 77 K is reported in fig. 3 (B parallel to the tape surface). The value of the normalized critical current is still higher than 0.3 at 1800 G.

The variation of the normalized measured magnetization value as a function of time is reported in fig. 4. In this case logarithmic decay was observed in the field of 500 G at 20 K. With a simple relationship relating an apparent activation U_0^* to the

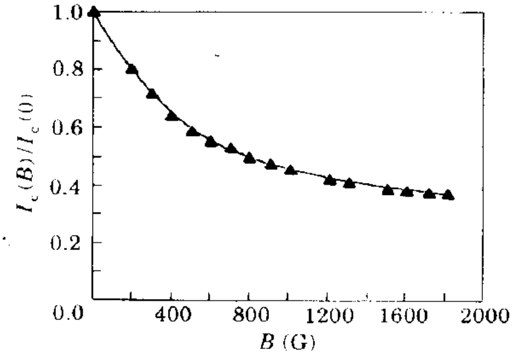

Fig. 3. – Normalized I_c vs. B at 77 K.

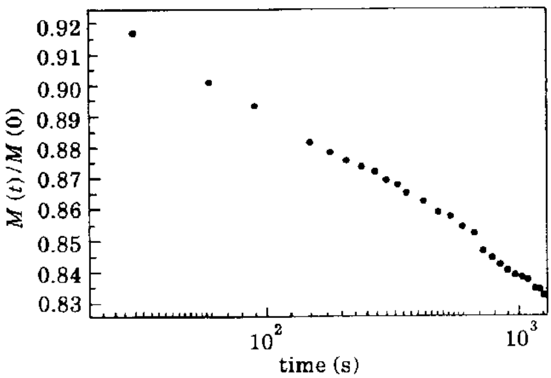

Fig. 4. – Variation of the normalized measured magnetization as a function of time at 20 K and 500 Oe.

measurable logarithmic creep rate

$$U_0^* = kT[(1/M_0)(\mathrm{d}M/\mathrm{d}\ln t)]^{-1},$$

where M_0 is the first measured value of the magnetization, a value of about 80 meV was obtained for U_0^*.

Figure 5 reports the critical current density obtained using Bean's critical-state model, as a function of the applied field (B is perpendicular to the surface of the tape) for temperatures of 40 and 60 K, whereas the insert reports the corresponding cycles of hysteresis.

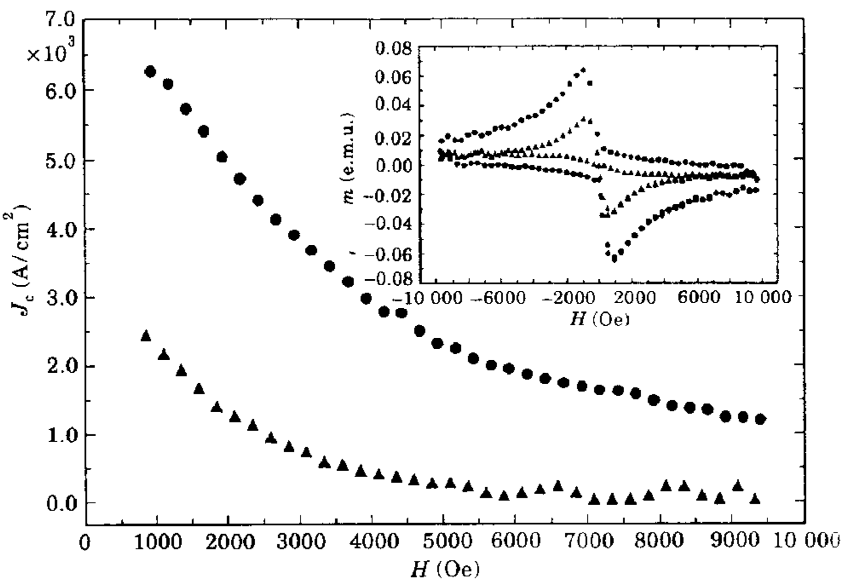

Fig. 5. – Critical current density as a function of the applied field. Inset: the magnetization cycle (● 40 K, ▲ 60 K)

4. – Conclusions.

Europa Metalli-LMI has developed a hot-extrusion process that allows Ag/BSCCO tapes in unit lengths of hundreds of metres to be obtained in a very reproducible way. The metallographic analysis performed showed that the layout is maintained constant and unaltered for the entire unit length. The advantages that this process of production brings, in terms of compaction of the superconducting powder, allow good results to be obtained in terms of transport properties right from the initial heat treatment. Such properties were observed on samples of 100 cm in length which, at nitrogen temperatures, gave critical current densities of $300\,A/cm^2$.
Magnetic characterizations were also performed on short samples and which are still in completion stage.

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