11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25
ICAM2009

Nano-Nb Precipitates in Cu matrix: Synthesis and Characterization

O. F. de Lima(1)* and R. L. de Almeida(1)

(1) Instituto de Física Gleb Wataghin, Universidade Estadual de Campinas, 13083-970 - Campinas, SP, Brazil, e-mail: delima@ifi.unicamp.br
* Corresponding author.

Abstract – We describe the preparation and characterization of granular samples formed by a regular distribution of almost spherical Nb particles having about 1000 nm in diameter, embedded in a Cu matrix. Magnetization, resistance and V×I measurements show clearly the combined superconducting behavior of the weak coupling and bulk regimes.

Early studies on samples of copper-rich niobium alloys [1] opened interesting possibilities for preparing mechanically reinforced Cu-Nb normal conductors [2], as well as Cu-Nb_3Sn superconducting wires. The sizes of Nb precipitates were found to be strongly dependent on cooling rate [3], while the sample temperature decreased from ~1800 ºC (liquid) to the peritectic point at 1090 ºC [4].

Here we present an innovative method were a Cu-xwt%Nb pellet is melted (T~1800 ºC) inside a conical radiofrequency coil and dropped inside a water-cooled Cu crucible. The cooling rate was estimated to be 2800 ºC/s, producing a regular distribution on Nb precipitates nearly of spherical shapes, with diameters typically around or below 1000 nm (Fig. 1). The pellets were initially suspended by a thin tungsten wire and dropped down when a homogeneous liquid phase was attained. Plate-like samples having typically an area of 10 mm^2 and 0.1 mm in thickness were then obtained. Next, rectangular pieces (~ 5×1.5×0.1 mm^3) were cut for inductive and transport measurements. Magnetization, resistance and V×I curves were measured with a SQUID and PPMS machines at low temperatures (T<15 K). The results show a typical superconducting response from a bulk Nb sample, superimposed to signatures of a weak coupled system that could be interpreted as a Josephson coupling between the 3D arrays of Nb particles.

Fig. 2 shows the H×T diagram, with an H_{c2} line defined at the onset of transition, associated with a bulk behavior of the Nb particles. Due to a solid solution of Cu in Nb the critical temperature of 8.3 K is about 1 K below the typical value for pure Nb. The M×T curves (inset), for magnetic fields below 200 Oe, display a clear knee in its ZFC part. This is associated to an abrupt loss of phase coherence between Nb particles, which favors an abrupt penetration of magnetic flux at $T_J \approx T_c$. The H_J line was then evaluated by taking this crossover point for several M×T curves. The M×H and V×I curves provide also clear signatures of the weak coupled regime and will be presented at the conference.

We acknowledge the support from Brazilian science agencies CNPq and FAPESP. We also thank to Dr. A. A. Coelho for a valuable help in the samples preparation.

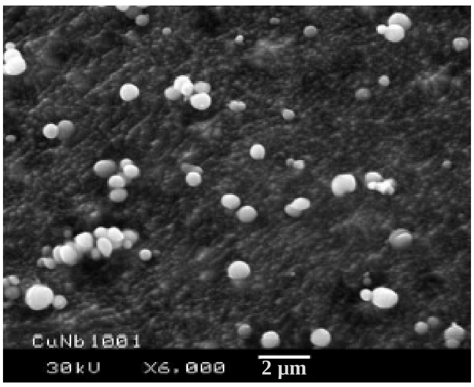

Figure 1: SEM picture of an etched Cu-10wt%Nb sample. Spherical Nb particles are shown.

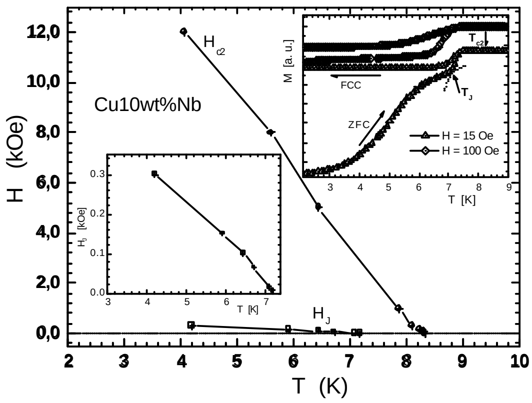

Figure 2: Critical fields lines extracted from M × T curves (upper inset). The lower inset is a magnified view of the H_J×T line.

References

[1] C. C. Tsuei, Science **180** (1973) 57 – 58; C. C. Tsuei and L. R. Newkirk, J. Mat. Sci. **8** (1973) 1307 – 1314.
[2] V. I. Pantsyrny, A. K. Shikov, V. E. Vorobieva, N. E. Khlebova, N. I. Kozlenkova, V. A. Drobishev, I. I. Potapenko, N. A. Beliakov, and M. V. Polikarpova, IEEE Trans. Appl. Supercond. **18** (2008) 616 – 619.
[3] J. L. Fihey, P. Nguyen-Duy, and R. Roberge, J. Mat. Sci. **11** (1976) 2307 - 2311.
[4] O. F. de Lima, M. Krehl and K. Schulze, J. Mat. Sci. **20** (1985) 2464 - 2470.