Highlights

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Investigation of inter-grain critical current density in $Bi_2Sr_2CaCu_2O_{8+d}$ superconducting wires and its relationship with the heat treatment protocol

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We investigate the effect of each different heat treatment stage in the fabrication of $Bi_2Sr_2CaCu_2O_{8+d}$ superconducting wires on intra-grain and inter-grain superconducting properties. We measure magnetic critical temperature T_c values and transport critical current density J_c at temperatures from 4 K to 40 K and in fields up to 7 T. From an analysis of the temperature dependence of the self-field critical current density $J_c(T)$ that takes into account weak link behavior and proximity effect, we study the grain boundaries (GB) transparency to supercurrents and we establish a relationship between GB oxygenation in the different steps of the fabrication process and the GB transparency to supercurrents. We find that grain boundary oxygenation starts in the first crystallization stage, but it becomes complete in the plateau at 836 °C and in slow cooling stages, and is further enhanced in the prolonged post annealing step. Such oxygenation makes GBs more conducting, thus improving the inter-grain J_c value and temperature dependence. On the other hand, from the inspection of the T_c values in the framework of the phase diagram dome, we find that grains are oxygenated already in the crystallization step up to the optimal doping, while successive slow cooling and post annealing treatments further enhance the degree of overdoping, especially if carried out in oxygen atmosphere rather than in air.

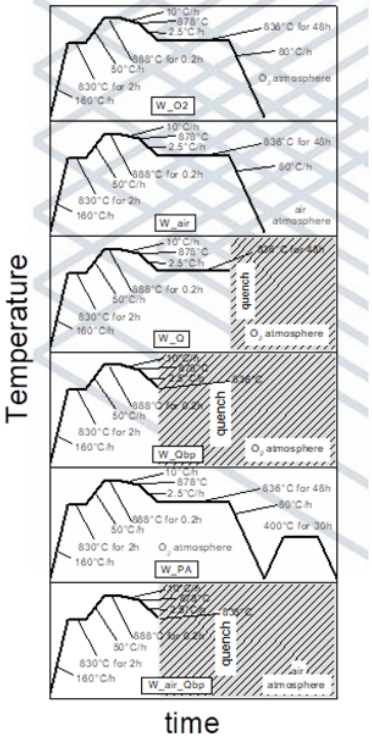
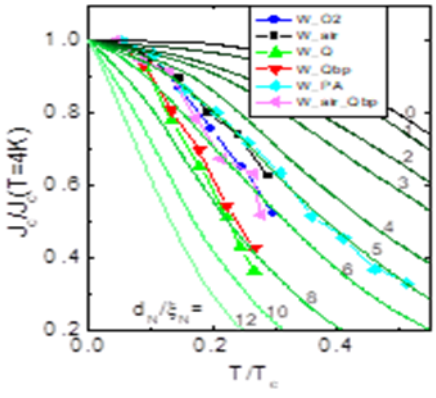


Fig.1: Temperature treatment protocols



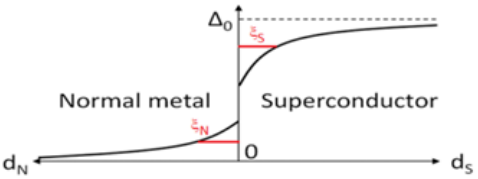


Fig.2: Left: Temperature dependence of normalized J_c, compared to predictions of models for proximity effect at grain boundary weak links, for different values of the ratio d_N/x_N. Right: sketch of the proximity effect, illustrating the meaning of the parameters d_N (thickness of the normal layer) and x_N (coherence length of the normal layer).