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Electrical transport effects due to oxygen content modifications in a $Bi_2Sr_2CaCu_2O_{8+\delta}$ superconducting whisker

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Abstract
We report a set of resistivity measurements along the *a*-axis of a $Bi_2Sr_2CaCu_2O_{8+\delta}$ microscopic superconducting whisker. The effect of the storage environment on sample ageing has been studied, considering both an air atmosphere at 273 K and a helium atmosphere at about 300 K for an overall storage time of about 100 days. It is clearly shown that the material underwent a remarkable resistivity increase of 26% at 260 K accompanied by a decrease in the critical temperature of 0.6 K during the whole ageing period. The helium atmosphere increased the average process rate by about two orders of magnitude. The present results are in agreement with previous findings on room temperature structural modifications in $Bi_2Sr_2CaCu_2O_{8+\delta}$ whiskers and can be ascribed to oxygen depletion phenomena from the material.

1. Introduction

In the past, the Bi–Sr–Ca–Cu–O material has been thoroughly investigated both in the bulk polycrystalline form and in the shape of large single-crystal samples. Modifications of the carrier density induced by changes in the oxygen content have been studied for these kinds of samples, especially for the $Bi_2Sr_2CaCu_2O_{8+\delta}$ phase of the system [1–7].

Only recently have some papers been published concerning the carrier density variation for whisker-like crystals [8–12]. This delay is probably due to the micrometric size of the samples, which makes them hard to manage and implies various difficulties in many measurement techniques. In order to avoid these problems, many researchers focused their efforts on the development of new synthesis techniques to enlarge the samples sizes, but in many cases these procedures resulted in defective or biphasic samples, i.e. containing both the $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) and the $Bi_2Sr_2Ca_2Cu_3O_{10+\epsilon}$ (Bi-2223) phases [13–16]. This is a major problem because, in order to deeply understand the Bi–Sr–Ca–Cu–O whisker system on the whole, it is very important to study whiskers characterized by a small amount of defects and by an almost single crystalline structure, which is typically achieved only in single phase samples with micrometric cross-sectional areas [17–19].

Such an almost ideal structure has been considered particularly attractive for a number of complex applications and experiments, which many research groups are currently pursuing. Among them, we can mention the possible fabrication of long stacks of intrinsic Josephson junctions (IJJs) by means of focused ion beam etching [20, 21] and the production of submicrometric SQUIDs [9, 22]. The high crystal quality of whisker samples has also opened new perspectives in the study of several quantum physics topics such as the symmetry of the order parameter, macroscopic quantum tunnelling and the Josephson vortex lattice [23–28].