Electrical transport effects due to oxygen content modifications in a 
Bi$_2$Sr$_2$CaCu$_2$O$_{8+\delta}$ superconducting whisker

Stefano Cagliero$^1$, Angelo Agostino$^2$, Elisabetta Bonometti$^2$ and Marco Truccato$^1$

$^1$ NIS-Centre of Excellence, Dipartimento di Fisica Sperimentale, and CNISM UdR Torino Università, Via P Giuria 1, I-10125, Torino, Italy
$^2$ NIS-Centre of Excellence, Dipartimento di Chimica Generale ed Organica Applicata, and CNISM UdR Torino Università, Corso Massimo D'Aze-glò 48, I-10125, Torino, Italy

E-mail: cagliero@ph.unito.it

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Abstract

We report a set of resistivity measurements along the $a$-axis of a 
Bi$_2$Sr$_2$CaCu$_2$O$_{8+\delta}$ 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$_2$Sr$_2$CaCu$_2$O$_{8+\delta}$ 
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$_2$Sr$_2$CaCu$_2$O$_{8+\delta}$ 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 im-
plies 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 en-
large the samples sizes, but in many cases these procedures 
resulted in defective or biphasic samples, i.e. containing both 
the Bi$_2$Sr$_2$CaCu$_2$O$_{8+\delta}$ (Bi-2212) and the Bi$_2$Sr$_2$Ca$_2$Cu$_3$O$_{10+\epsilon}$ (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 al-
most 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].