

Crystalline instability of Bi-2212 superconducting whiskers near room temperature

Stefano Cagliero · Angelo Agostino · Mohammad Mizanur Rahman Khan · Marco Truccato · Francesco Orsini · Massimo Marinone · Giulio Poletti · Alessandro Lascialfari

Received: 25 March 2008 / Accepted: 17 September 2008 / Published online: 11 October 2008
© Springer-Verlag 2008

Abstract We report new evidences for the thermodynamic instability of whisker crystals in the Bi–Sr–Ca–Cu–O (BSCCO) system. Annealing treatments at 90°C have been performed on two sets of samples, which were monitored by means of X-Rays Diffraction (XRD) and Atomic Force Microscopy (AFM) measurements, respectively. Two main crystalline domains of $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+x}$ (Bi-2212) were identified in the samples by the XRD data, which underwent an evident crystalline segregation after about 60 hours. Very fast dynamics of the surface modifications was also described by the AFM monitoring. Two typologies of surface structures formed after about 3 annealing hours: continuous arrays of dome shaped bodies were observed along the edges of the whiskers, while in the central regions a dense texture of flat bodies was found. These modifications are described

in terms of the formation of simple oxide clusters involving a degradation of the internal layers.

PACS 68.70.+w · 74.72.Hs · 74.62.Bf · 61.05.Cp · 68.37.Ps

1 Introduction

In recent years, superconducting whisker crystals in the $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ phase (Bi-2212) of the Bi–Sr–Ca–Cu–O system (BSCCO) have attracted the attention of many researchers as ideal structures for the study of fundamental physics topics [1–3] and for micro-devices applications exploiting the Intrinsic Josephson Junction (IJJ) structure of this compound [4, 5].

However, careful experimental observations have proved that such microscopic crystals are unstable at ambient conditions [6–8]. For instance, structural modifications involving Cu cation migration processes along their *b*-axis have been found to take place after a 40 days ageing at room temperature [6]. Moreover, since the *c*-axis values of cuprate materials is known to be a significant parameter for the identification of the doping level [9–11], the 32 Å value found for the aged whisker by micro-X-rays diffraction (μ -XRD) measurements was interpreted as corresponding to a highly underdoped state of the material, compared to the usual ≈ 30.6 Å values reported in literature [11].

These changes can also be connected with peculiar electronic behaviors, like the increase of the resistivity in aged $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ phase (Bi-2212) whiskers and the decrease of their critical temperature (T_c) [8], or with an interplay between the $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ and the $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10+\delta}$ phases, which was observed in bi-phasic samples [7]. An important role of the surface could be hypothesized for microscopic whisker-like crystals because of their

S. Cagliero (✉) · A. Agostino · M.M.R. Khan
“NIS” Centre of Excellence, Dip. Chimica Generale e Chimica Organica, and CNISM UdR, Torino Università, C.so Massimo D’Azeglio 48, 10125 Turin, Italy
e-mail: cagliero@to.infn.it

S. Cagliero · M.M.R. Khan · M. Truccato
“NIS” Centre of Excellence, Dip. Fisica Sperimentale, and CNISM UdR, Torino Università, Via P. Giuria 1, 10125 Turin, Italy

F. Orsini · M. Marinone · G. Poletti · A. Lascialfari
Istituto di Fisiologia Generale e Chimica Biologica, Università degli Studi di Milano, 20134 Milan, Italy

F. Orsini · M. Marinone · G. Poletti · A. Lascialfari
CNR-INFN-S3 NRC, 41100 Modena, Italy

A. Lascialfari
INFN-CNR c/o Dipartimento di Fisica A. Volta, Università degli Studi di Pavia, Via Bassi 6, 27100 Pavia, Italy