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# Control of the oxygen doping in Bi-2212 whiskers by means of their synthesis process

**M M Rahman Khan[1,2], S Cagliero[1,2], A Agostino[1], M Beagum[1,2], C Plapcianu[1,2] and M Truccato[2]**

[1] CNISM and NIS-Centre of Excellence, Department of General and Organic Chemistry, University of Torino, Corso Massimo D'Azeglio 48, I-10125, Torino, Italy
[2] CNISM and NIS-Centre of Excellence, Department of Experimental Physics, University of Torino, Via P Giuria 1, I-10125, Torino, Italy

E-mail: truccato@to.infn.it

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**Abstract**

Direct evidence of oxygen doping control in single phase $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) whiskers is reported, along with the changes in their structural properties obtained by varying the growth temperature of the synthesis process in the range from 843 to 872 °C. The as-grown whiskers were investigated by means of x-ray powder diffraction (XRPD), electrical transport measurements, scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDS). The XRPD measurements showed that the value of the *c*-axis lattice parameter increases from 30.556 to 30.640 Å when increasing the growth temperature, which indicates different oxygen doping levels spanning from the slightly overdoped to the nearly optimally doped regimes. Such results are also confirmed by the electrical characterizations, which revealed a typical relationship among resistivity ($\rho_{ab}$), superconducting critical temperature ($T_c$), and *c*-axis value. The growth of CuO crystals has also been identified during this study, with a maximum yield in the range 860–864 °C, where also a slope change in the *c*-axis behavior has been found, implying a possible correlation between the two phenomena. Therefore, by changing the synthesis growth temperature, one can provide an effective way to tune the whisker electrical transport properties.

## 1. Introduction

Suitable materials for the fabrication of terahertz (THz) radiation sources represent a challenging research subject, due to various application domains such as radiation technologies and physical, biological, medical and applied sciences [1–3]. Materials able to fulfil the demand for fabrication of THz radiation sources are currently being intensively studied. Several works can be found demonstrating the possibility to produce or sense coherent THz radiation from layered high-temperature superconductors (HTSCs) due to their intrinsic Josephson junction (IJJ) properties [1, 4, 5]. For instance, the $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) phase of the BSCCO system exhibits such features and has been widely studied in previous papers [6–8].

In this framework, Bi-2212 crystals in the form of whiskers represent good candidates for device fabrication because of their high crystalline quality and microscopic sizes [9]. Many mechanisms have already been proposed for their growth so far, as summarized in the review by Badica *et al* [10]. Among the already performed experiments, many studies investigated the influence of the synthesis temperature, especially from the point of view of its relationship with the precursor cationic composition [11–15]. However, all of them were much more focused on the amount and length of the produced material than on its structural and electronic properties, so that a clear understanding of their correlation with the synthesis temperature is currently lacking [10].

On the other hand, the ability to control the IJJ parameters of Bi-2212 whiskers is very important in order to fabricate reliable devices. So far, all of the achievements in this field have been obtained by means of post-annealing treatments to be applied after the growth stage. Typical treatments consisted of post-annealing temperatures around 400 °C [8, 16], although

 