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Influences of Pb content on the critical current of Bi-2223 multi-filamentary tapes

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ABSTRACT

Multifilament Bi-2223/Ag tapes with different Pb contents in precursor powders were fabricated by powder in tube (PIT) method. The influence of Pb contents on the phase formation, microstructure and critical current density of Bi-2223/Ag tapes were systematically investigated. X-ray photoelectron spectroscopy (XPS) demonstrated that the content and oxidation states change of Pb ions can influence the carrier concentration of superconducting phase. Scanning electron microscopy (SEM) revealed that the variation of Pb content can lead to the difference in microstructure due to the change of thermodynamic properties. The results showed that with the Pb content of $x=0.35$ in the nominal composition of $Bi_{2-x}Pb_xSr_2Ca_2Cu_3O_y$, proper content of liquid phase can be formed during the sintering process, thus maximum critical current (I_c) was obtained. The correlation between the transport property, carrier concentration and Pb content was discussed.

1. Introduction

Since the discovery of the 110 K superconducting $Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ (Bi-2223) phase in 1988, intensive research efforts have been focused on optimizing its phase purity and microstructure [1–5]. Lead addition to the Bi–Sr–Ca–Cu–O system was found to enhance diffusion, accelerate reaction kinetics and give stability to the Bi-2223 phase [6–8], and the Pb doping level in precursor powders is directly correlated to the amount and distribution of liquid phase formed during the heat treatments, which can promote the grain growth by facilitating the ion diffusion, and heal cracks induced by the intermediate deformation [9,10]. Pb content within the range of $x=0.3$–0.4 in the composition of $Bi_{2-x}Pb_xSr_2Ca_2Cu_3O_y$ has been suggested [11]. In this work, Influences of Pb contents on the microstructure development, critical temperature and critical current of Bi-2223/Ag tapes was systematically discussed.

2. Experimental

The precursor powders with nominal composition of $Bi_{2-x}Pb_xSr_2Ca_2Cu_3O_{10+\delta}$ (Bi,Pb-2223, $x=0.30$–0.40) were prepared by the two-powder process [12]. $Bi_{2-x}Pb_xSr_2CaCu_2O_{8+\delta}$ (Bi,Pb-2212) powders were prepared using a co-precipitation process with the raw materials of Bi_2O_3, PbO, $SrCO_3$,$CaCO_3$ and CuO (> 99.9%), and the calcinations processed at 750–830 °C for

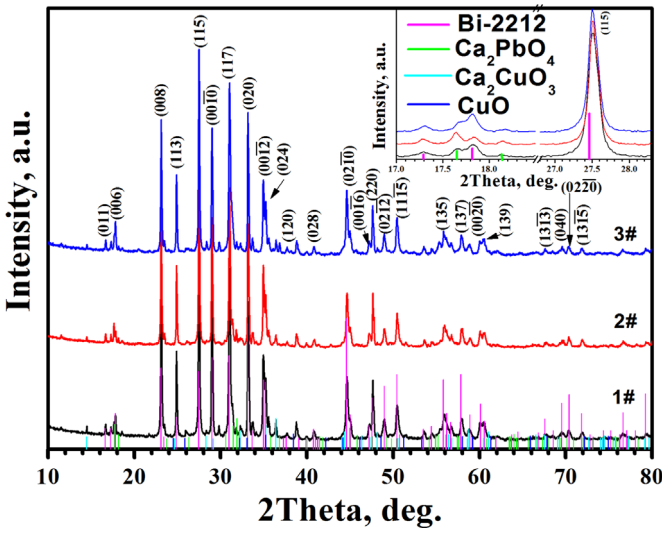

Fig. 1. XRD patterns of precursor powders with Pb content of $x=0.30$ (1#), 0.35 (2#), and 0.40 (3#).

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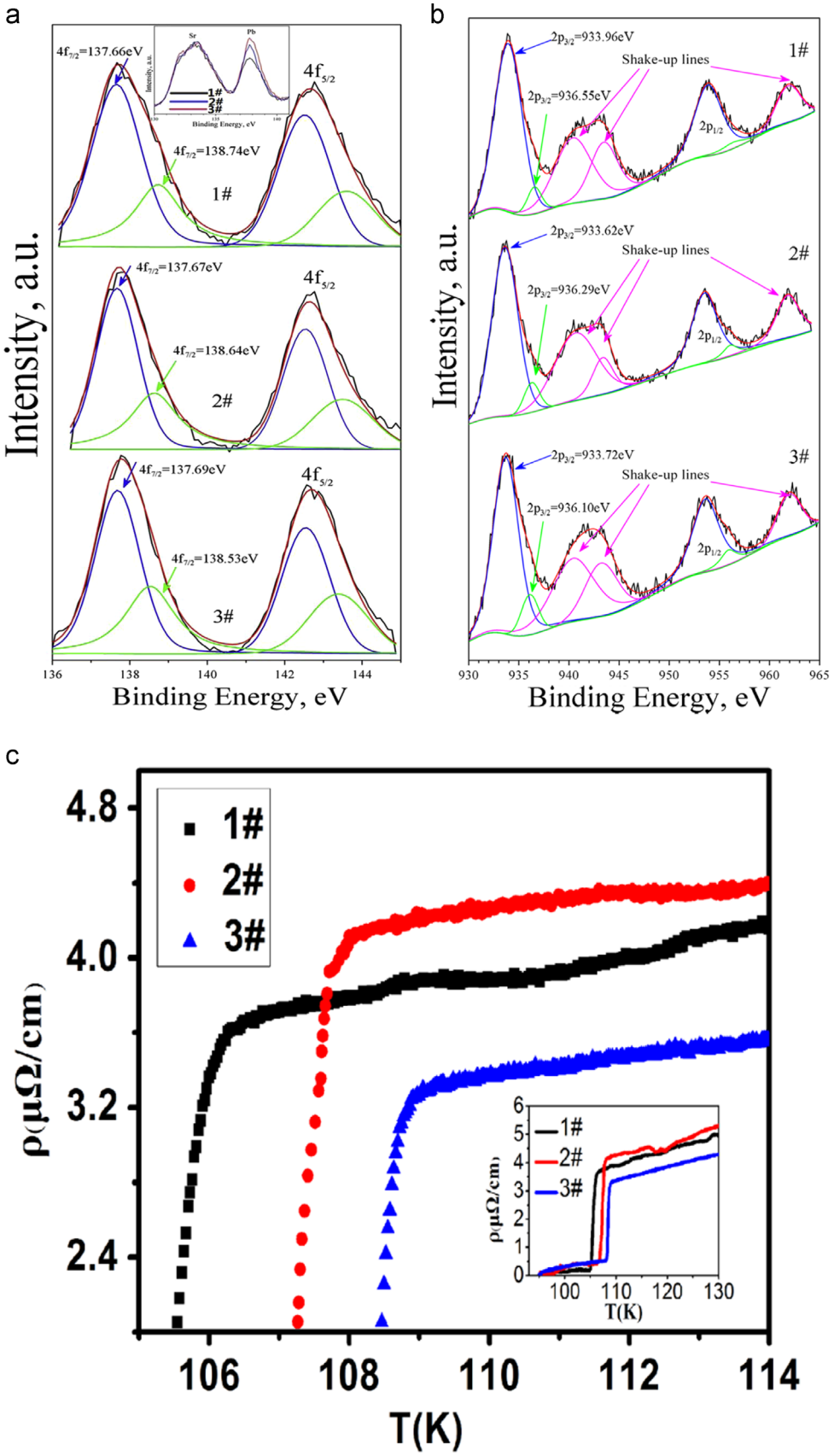

Fig. 2. XPS of (a) Pb (b) Cu ions in precursor powders and (c) temperature-resistivity curves of Bi-2223 tapes with Pb content of $x=0.30$ (1#), 0.35 (2#), and 0.40 (3#). In (a), blue curves represents to the Pb^{4+} peaks, green ones for Pb^{2+} peaks; in (b), blue curves represents to the Cu^{2+} peaks, green ones for Cu^{3+} peaks, pink ones for the shake-up lines in Cu spectra. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)