Available online at www.sciencedirect.com
SCIENCE DIRECT®
Physica C 408–410 (2004) 50–51
PHYSICA C
www.elsevier.com/locate/physc

Defective structure in the high-T_c superconductor Hg-1234

Z.P. Luo [a], Yang Li [b,c,d,*], H. Hashimoto [e], H. Ihara [f], A. Iyo [f], K. Tokiwa [f], G.H. Cao [c], J.H. Ross Jr. [b], J.A. Larrea J. [d], Elisa Baggio-Saitovitch [d]

[a] *Microscopy and Imaging Center, Texas A&M University, College Station, TX 77843-2257, USA*
[b] *Department of Physics, Texas A&M University, College Station, TX 77843, USA*
[c] *Department of Materials Physics, University of Science and Technology Beijing, Beijing 100083, China*
[d] *Centro Brasileiro de Pesquisas Fisicas, Rua Dr. Xavier Siguad, 150, 22290-180 Rio de Janeiro, RJ, Brazil*
[e] *Okayama University of Science, Okayama 700, Japan*
[f] *Electrotechnical Laboratory, 1-1-4, Umezono, Tsukuba, Ibaraki 305, Japan*

Abstract

Samples with different fractions of structural modulation were synthesized in order to study the effect of a defective modulated structure on the critical temperature T_c of Hg-1234. Electron microscopy revealed the existence of modulated and unmodulated Hg-1234 structures in these samples. Measurements of critical temperature T_c on these samples revealed that the structural modulation significantly suppresses the T_c. For the Hg-1234 sample without the structural modulation, the T_c was found to be close to the highest T_c for the Hg-1223 phase.

Keywords: Superconductor; Hg-1234; Structure; Defect; Critical temperature T_c

1. Introduction

The mercury-based superconductors $HgBa_2Ca_{n-1}Cu_nO_{2n+2+\delta}$ are of great interest since the highest critical temperature T_c was measured in this system for Hg-1223 [1]. The critical temperatures were reported as $T_c = 94$ K for Hg-1201 ($n = 1$) [2], $T_c = 121$ K for Hg-1212 ($n = 2$) [3], $T_c = 133$ K for Hg-1223 ($n = 3$) [1]; however, for the fourth member Hg-1234 ($n = 4$), the T_c was reported as $T_c = 126$ K [4] or $T_c = 116$ K [5]. With an increasing n of the conductive Cu–O layers, the T_c increases until Hg-1223 and then decreases unexpectedly. Our recent work revealed novel modulated structure in the Hg-1234 phase [6]. In this work, T_c measurements were carried out on the Hg-1234 samples and an attempt was made to correlate the T_c's with the phase structures.

2. Experimental

Samples were synthesized under different conditions, for details see [6]. Among them, sample A was prepared at 1323 K and 3.5 GPa for 3 h, and sample E, 1223 K and 3.5 GPa for 3 h. The TEM samples were prepared by depositing crushed powders on Cu grids coated with carbon films, then examined in JEM-4000EX with a resolution of 0.17 nm at 400 kV. DC magnetic susceptibility measurements were performed on samples with a Quantum Design MPSP-2 SQUID magnetometer operating in the temperature range of 5–300 K at 100 Oe.

3. Results and discussion

The samples prepared under different conditions [6] exhibit different structural features as revealed by

* Corresponding author. Address: Department of Physics, Texas A&M University, College Station, TX 77843, USA. Tel.: +1-9798457823; fax: +1-9798452590.
E-mail addresses: luo@tamu.edu (Z.P. Luo), ylibp@hotmail.com (Y. Li).

0921-4534/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.physc.2004.02.037

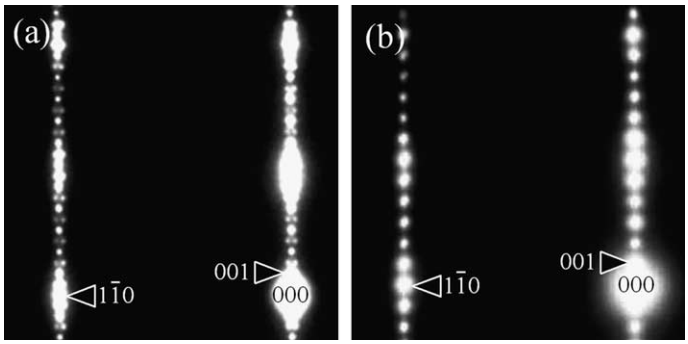

Fig. 1. Electron diffraction patterns along [1 1 0] from the sample A (a) and E (b) respectively.

electron microscopy. Despite of the trace of impurity phases, there exist two distinct different Hg-1234 structures: one is the modulated structure as reported previously [6], and another one is the parent phase without structural modulation. Two typical examples of the samples A and E are given here. In the sample A prepared at higher temperature (1323 K), a large fraction of modulated structure was observed, as shown by the electron diffraction pattern in Fig. 1a along the [1 1 0] zone axis, where extra reflections in pairs are present between the fundamental reflections, indicating the modulated structure. The modulation vector was determined as $\mathbf{q} = (0.036–0.048)\mathbf{b}^* + 0.5\mathbf{c}^*$. In the sample E prepared at a lower temperature of 1223 K, no evidence of the modulated structure was found from the electron diffraction patterns or high-resolution images. A typical example of the electron diffraction pattern along the [1 1 0] zone axis is shown in Fig. 1b, where only the fundamental reflections are present.

The DC magnetic susceptibility measurements are made for these samples as shown in Fig. 2. It is found that the T_c is strongly related to their structural perfection. For the sample A with a large fraction of modulated structure, the T_c is measured as 117 K, which is close to the T_c of 116 K reported by Loureiro et al. [5]. However for the sample E without structural modulation, the T_c is measured as high as 131 K, which is close to the highest T_c of Hg-1223 (133 K) [1]. It is evident that the defective structural modulation significantly decreases the critical temperature (Fig. 2).

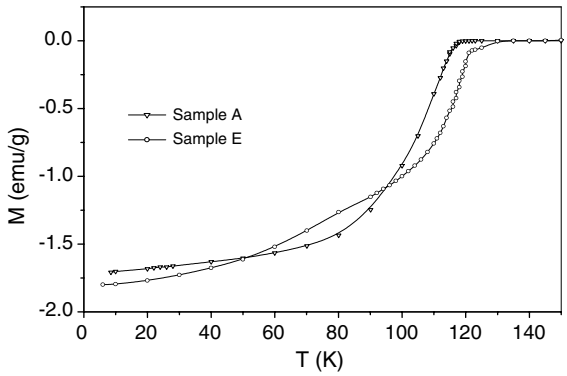

Fig. 2. DC magnetic susceptibility of the samples A and E.

Acknowledgements

ZPL is grateful to Prof. E. Sukedai of Okayama University of Science for technical assistance with the microscopy work, and YL, GHC acknowledges support from the Welch Foundation (grant no. A-1526), TAMU through TITF and the Excellent Young Teachers Program of MOE, China (EYTP).

References

[1] A. Schilling, M. Cantoni, J.D. Guo, H.R. Ott, Nature 363 (1993) 56.
[2] S.N. Putilin, E.V. Antipov, O. Chmaissem, M. Marezio, Nature 362 (1993) 226.
[3] S.N. Putilin, E.V. Antipov, M. Marezio, Physica C 212 (1993) 266.
[4] E.V. Antipov, S.M. Loureiro, C. Chaillout, J.J. Capponi, P. Bordet, J.L. Tholence, S.N. Putilin, M. Marezio, Physica C 215 (1993) 1.
[5] S.M. Loureiro, E.V. Antipov, E.M. Kopnin, M. Brunner, J.J. Capponi, M. Marezio, Physica C 257 (1996) 117.
[6] Z.P. Luo, H. Hashimoto, H. Ihara, A. Iyo, K. Tokiwa, Phil. Mag. Lett. 79 (1999) 429.