S. TOLENDIULY, K. ALIPBAYEV, S. FOMENKO, A. SOVET, A. ZHAUYT

ISSN 0543-5846
METABK 60(1-2) 137-140 (2021)
UDC – UDK 537.312.62-536.45:546.641.431.56.21:536.425:529.7.4=111

PROPERTIES OF HIGH-TEMPERATURE SUPERCONDUCTORS (HTS) AND SYNTHESIS TECHNOLOGY

Received – Primljeno: 2020-08-27
Accepted – Prihvaćeno: 2020-10-28
Preliminary Note – Prethodno priopćenje

The main results for the synthesis and study of superconducting high-temperature materials based on cuprates obtained by high-temperature synthesis are presented. The influence of the ratio of the primary components, time and exposure temperature on the output of the superconducting phase (Y123) in the composition was studied. It was found that the initial ratio of components, annealing temperature and aging time have a direct impact on the qualitative and quantitative formation of the conductive phase. The chemical, phase composition and morphology of the obtained samples were carefully studied. Optimal result (maximum conductive phase in Y-Ba-Cu-O system (Y123) size) at a temperature of 920 °C with a retention time of 6 hours.

Keywords: high temperature superconductors, YBa2Cu3O7-d, phase, time, aerospace

INTRODUCTION

Currently, technical devices based on high-temperature superconductors (HTS) are being intensively developed. Designs of non-contact superconducting supports [1], universal systems of non-contact communication between space objects, berthing and contact systems of space aircraft (SA), hermetic movement inputs, communication devices with variable rigidity, large space structures with non-contact connections [2], SA radiation protection systems, various energy and instrumental systems for working on the moon are being developed. Changes in the physical and chemical properties of nanomaterials due to different synthesis than in bulk materials [3]. The most popular materials are high-temperature superconductors (HTS). The electric current changes linearly due to changes in the chemical composition, the interaction of the granules and the medium between the grains. The most popular high-temperature superconductors are $YBa_2Cu_3O_{7-\delta}$. Since it is a multicomponent compound, it is necessary to observe the synthesis conditions to increase probability of the expected phase [4].

When synthesizing, materials that have the necessary properties are obtained by changing their parameters.

MATERIALS AND METHODS

Obtaining high-temperature superconductivity is one of the most problematic issues today. The complex conductivity material ybacuo nanomodified was obtained on the basis of mixing microcrystalline powder and nanoparticles [5]. In different concentrations, micro-and nanoparticles were mixed and then pressed and burned. First of all, YBaCuO microcrystalline ybacuo powder is made using ceramic technology, which consists of several levels.

Preparation of microcrystalline YBaCuO powder:

$$\frac{1}{2}Y_2O_3 + 2BaO_2 + 3Cu + \frac{1}{2}\left(\frac{3}{2} - x\right) = YBa_2Cu_3O_{7-\delta}$$

Purity based on the solid phase method 99,9 % Y_2O_3 (size 0,03 μm), BaO_2 (size 1,5 - 2 μm) and Cu (size 40 - 60 nm) powders are obtained in different ratios. The powders are measured on an electronic VLE-134 meter and mixed uniformly in a ceramic vessel [6]. The finished powder is placed in a press form and pressed at a pressure of 0,15 MPa. First-class combustion of raw materials was carried out. A process designed to ensure the necessary stoichiometry of the samples to be removed and the powders to be uniform.

$YBa_2Cu_3O_{7-\delta}$ the high-temperature complex conductor is obtained in 2 different ways based on the solid phase method. СНОЛ 40 / 1 180 brand muffle furnace, РТ-1200ВУ brand tube oven. $YBa_2Cu_3O_{7-\delta}$ the synthesis of microcrystalline powders is between 600 – 920 °C and consists of repeated firing. HTS $YBa_2Cu_3O_{7-\delta}$ melting point 920 °C. Compared to other studies, the range of HTS is 920 – 1 020 °C. In scientific work, the melting point of ceramics is 920 °C, and at work 980 °C, – 993 °C and – 1 020 °C specified. The presence of different temperatures depends on the time of heating, burning and cooling, as well as on the additional phases formed along with co, for example depending on the Y_2BaCuO_5, CuO. The muffle furnace SNOL 40 / 1 180 was heated to 920 °C for 2 hours. Burning was carried out for 4, 6 and 8 hours is shown in Table 1. The fin-

S. Tolendiuly, (s.tolendiuly@satbayev.university), S. Fomenko, Satbayev University, Almaty, Kazakhstan
K. Alipbayev, A. Covet, A. Zhauyt, Almaty University of Power Engineering and Telecommunications, Almaty, Kazakhstan

Table 1 **Ways to obtain experimental samples of the muffle furnace**

Sample name	First-Order burning			Second-order burning		
	T / 0C	Burning time / hours	Sample shape	T / 0C	Burning time / hours	Sample shape
MP-1	920	8	powder	920	8	tape
MP-2	920	6	powder	920	8	tape
MP-3	920	4	powder	920	8	tape
MP-4	920	8	powder	920	6	tape
MP-5	920	6	powder	920	6	tape
MP-6	920	4	powder	920	6	tape
MP-7	920	8	powder	920	4	tape
MP-8	920	6	powder	920	4	tape
MP-9	920	4	powder	920	4	tape
MP-10-14	920	6	tape	600	6	powder
MP-15-19	920	6	powder	600	6	tape

ished raw materials were pressed and burned in the second order [7]. Qualitative and quantitative composition of microcrystalline powders and products was analyzed by X-ray diffractometer (XRD) - DRON 4M.

The best structural analysis is shown in the MP-1 and MP-2 models. The MP-1 model was first fired at 920 °C for 8 hours, pressed at a pressure of 0,15 MPa for 8 hours at 920 °C. Our expected phase was 73,3 %. The expected phase of the MP-2 was 73,2 %, only the first firing time of the MP-2 was 6 hours [8]. Y_{123} The optimum temperature for the production of HTS was shown to be 920 °C. During the second firing, the YBaCuO phase showed a low percentage at a temperature of 600 °C.

RESULTS AND DISCUSSION

The second method is in a tube furnace brand PT-1200VU $YBa_2Cu_3O_{7-\delta}$ a high-temperature superconductor was obtained. Obtained by means of a coupling furnace as a ratio of components Y_{123} a sample MP-1 showing a high mass size of the phase was obtained is shown in Figure 1.

It was found that the expected HTS depends not only on the firing time, but also on the shape of the sample. Purity 99,9 % micro Y_2O_3, BaO_2 and nano Cu powders were weighed and mixed in a ceramic vessel until a homogeneous mass is shown in Figure 2. The finished samples in the form of powder and tape were baked in a

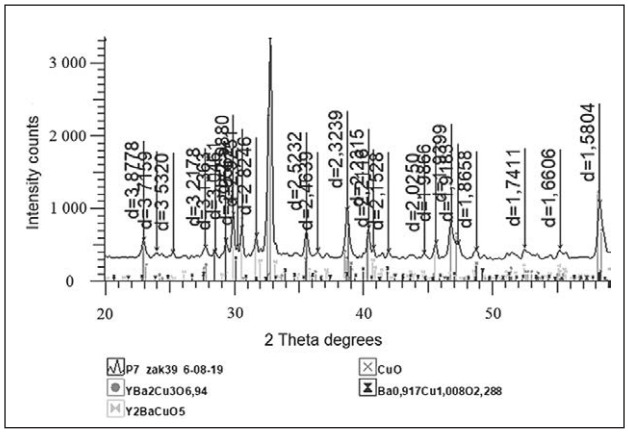

Figure 1 XRD analysis of MP-1

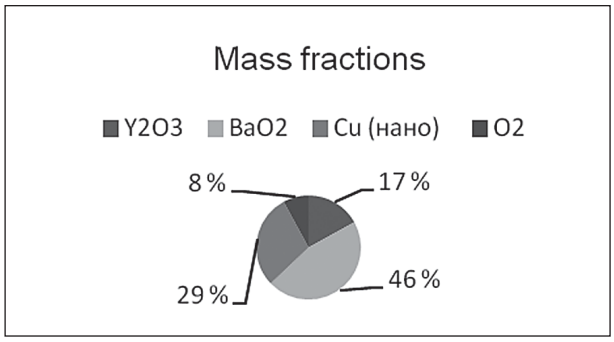

Figure 2 Mass fraction of the obtained components

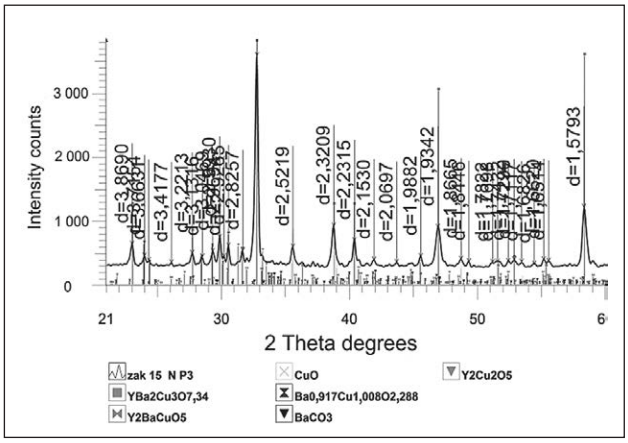

Figure 3 XRD analysis of the TP-3 sample

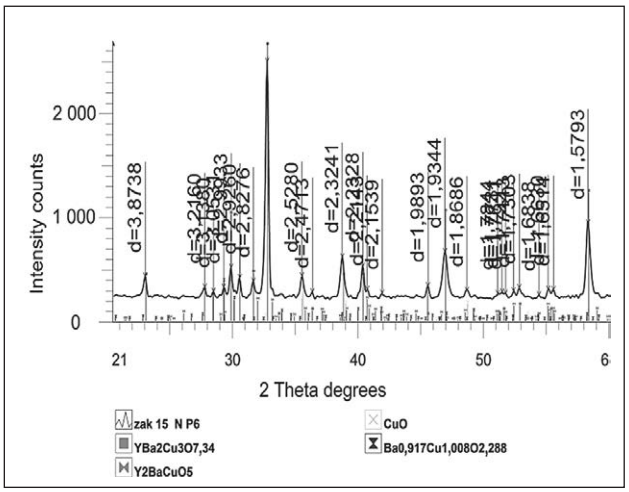

Figure 4 XRD analysis of the TP-6 sample

Table 2 **Methods of obtaining experimental samples in a tube furnace**

Sample name	First-Order burning			Second-order burning		
	T / °C	Burning time / hours	Sample shape	T / °C	Burning time / hours	Sample name
TP1	920	4	powder	920	4	tape
TP2	920	4	powder	920	6	tape
TP3	920	4	powder	920	8	tape
TP4	920	6	powder	920	4	tape
TP5	920	6	powder	920	6	tape
TP6	920	6	powder	920	8	tape
TP7	920	8	powder	920	4	tape
TP8	920	8	powder	920	6	tape
TP9	920	8	powder	920	8	tape

Table 3 **Results of (RFA) analysis**

Name samples	$YBa_2Cu_3O_{6,94}$ (Y_{123}) / mass %	CuO / mass %	$Y_2Cu_2O_5$ / mass %	Y_2BaCuO_5 / mass %
TP1	46,5	17,8	9,3	14,1
TP2	64,8	9,9	2,2	13,2
TP3	66,2	10,1	2,5	13,2
TP4	50,8	14,1	3,4	22,2
TP5	65,5	12,6	1,3	14,5
TP6	69,4	11,3	0	13,9
TP7	59,4	12,6	1,0	19,3
TP8	68,9	13,2	4,9	13,2
TP9	57,6	17	1,1	17,0

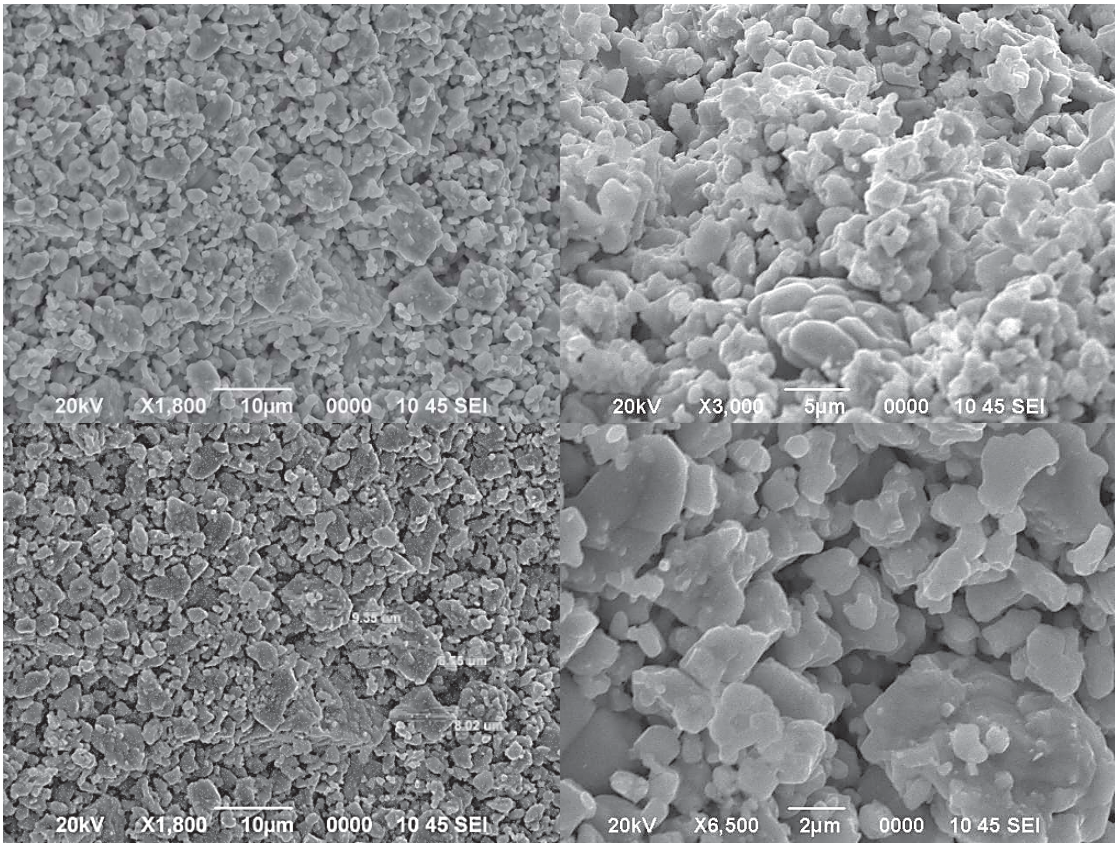

Figure 5 SEM drawings TP-6 components

tubular oven for 4, 6 and 8 hours is shown in Table 2. The expected phase was not determined in the baked samples in powder form. The highest 62 % by mass fraction was determined in the TP (D3) sample (see Table 3). The secondary firing was carried out at a temperature of 920 °C.

Qualitative and quantitative composition of microcrystalline powders and products was analyzed by X-ray diffractometer DRON 4M. According to the results of X-ray fluorescence analysis (RFA), the expected phase was determined with high mass index in TP-6 and TP-8 samples by X-ray structural analysis of HTS ob-

tained in a tubular furnace [3]. TP-5 and TP-3 were effective over time is shown in Figure 3.

Figure 4 shows the morphological properties of the TP-6 sample obtained in a tubular furnace were studied by a scanning electron microscopy (SEM) of the brand JED-2300. HTS $YBa_2Cu_3O_{7-\delta}$ the structure is observed to be porous is shown in Figure 5.

CONCLUSIONS

It was established that the initial ratio of components, annealing temperature and aging time directly affect the qualitative and quantitative formation of the conducting phase. According to the analysis of the conducted experiments Y-Ba-Cu-O the optimal composition (Y123) with the most conductive phase in the system is formed by a small amount of copper nanoparticles. Thus, we are made of copper nanoparticles Y-Ba-Cu-O we have shown the synthesis of the material as a new primary substance by a solid-phase process at a temperature of 920 °C for different exposure times. When using complex compounds as new raw materials, it was found that a high conductive phase can occur at a lower heating temperature and a holding time (6 - 8 hours). In addition, the results of XRD analysis, scanning electron microscopy (SEM) and RFA analysis show that the prepared samples have a good morphology without micropores, which proves the presence of a dense microstructure in the samples. It is obvious that dense conductors Y-Ba-Cu-O have a higher current density than low-density ones.

REFERENCES

[1] J. Nagamatsu, N. Nakagawa, T. Muranaka, Superconductivity at 39 K in magnesium diboride, Nature 410 (2001), 63–64.

[2] T. A. Prikhna, Modern superconductive materials for electrical machines and devices working on the principle of levitation, Fizika Nizkikh Temperatur 32 (2006) 5, 661–676.

[3] S. Tolendiuly, S. M. Fomenko, Z. A. Mansurov, G. Dannangoda, K. S. Martirosyan, Self-propagating high temperature synthesis of MgB_2 superconductor in high-pressure of argon condition, Eurasian Chemico-Technological Journal 19 (2017) 2, 177-181.

[4] S. Tolendiuly, S. M. Fomenko, R. G. Abdulkarimova, A. Akishev, Synthesis and superconducting properties of the MgB_2@BaO composites, Inorganic and Nano-Metal Chemistry 50 (2020) 5, 349 – 353.

[5] X. L. Wang, Significant enhancement of critical current density and flux pinning in MgB2 with nano-SiC, Si, and C-doping, Physica C 408 (2004), 63–67.

[6] F. S. Xiang, Evidence for transformation from δT c to δ l pinning in MgB2 by graphene oxide doping with improved low and high field Jc and pinning potential, Appl. Phys. Lett. 102 (2013), 152601–152605.

[7] R. Ribeiro, S. Budko, C. Petrovic and P. Canfield, Carbon Doping of Superconducting Magnesium Diboride, Physica C, 384 (2003) 3, 227-236.

[8] Sh. Chandra, G. Rajiv, R. S. Tiwari, O. Srivastava, S. Malik, Enhancement of flux pinning and high critical current density in graphite doped MgB_2 superconductor, Journal Appl. Phys. 102 (2007), 45-49.

Note: The responsible for England language is Aigerim Nauryzbayeva, Almaty, Kazakhstan