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Effects of Y_2O_3 on the property of copper based contact materials

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ABSTRACT

The copper based electric contact materials with multicomponent substance were obtained by powder metallurgy. The hardness and density of the samples increase with adding proper amount of Y_2O_3. Adding 1.5 wt.% Y_2O_3 the hardness of the sample reaches the maxim and the density of sample reaches the maximum by adding 2 wt.% Y_2O_3. In this paper, the effects of addition of Y_2O_3 on the performance of copper based contact materials were studied by metallographic microscope, XRD, SEM in details. Moreover, the mechanism of the effects was discussed.

1. Introduction

Electric contact materials are used in electric switches which switch on and off the current, therefore the performances of those materials have important effects on the running stability and service life of instruments [1,2]. Opening or breaking a contact pair switching system usually results in an arc being drawn between the contact pair. Due to electric arc energy, the surface of contact material would come up warming, melting, vaporizing, splashing and solidifying metallurgy process. Therefore contact materials not only need excellent electric contact properties, but also excellent mechanical properties and chemical stability. At present, electrical contact materials used in switching devices are commonly made from silver alloys because of the properties of minimizing contact welding and arc erosion during operation [3–7]. But silver is very expensive and is very difficult to be recycled from the contact materials, so developing a new material which does not contain silver is very desirable. The electrical conductivity and thermal conductivity of copper are similar to those of silver and the resource of copper is abundant, so copper can become the substitute of sliver [8]. Cu-based contact material is often applied to vacuum breaker or high voltage normally closed switch. Copper tends to be oxidized and the oxidized derivative is nonconductive. If copper is used for contact material, its oxidized derivatives will cause the contact resistance to rise sharply, and then the arc erosion become serious and the lifetime get shorten when the switch is operated.

Based on the performance requirement of contact materials, this paper developed a new high-performance copper based contact material by powder metallurgy. Y_2O_3 was used as the dispersion-strengthening phase of the copper alloy owning to the good wettability between the liquid copper and Y_2O_3 phase and the good chemical stability [9]. The effects of Y_2O_3 on the performances of copper based materials were studied in this paper.

2. Experiment

In these experiments, copper powder (degree of purity: 99.7%) is used for matrix materials. B_4C is used as the antifriction component. Bi is used as the arc extinction component. Table 1 shows the particle size of copper powders. Experiments adopt 700 MPa pressure making into green bodies. The sinter temperature is about 960 °C; holding time 2 h [10–13].

The particle size of copper was measured by Beckman Coulter LS 13 320. Hardness was measured by brinell hardness tester. The crystal structures of samples were studied by X-ray diffraction (XRD, D8-ADVANCE, Germany) with Cu Kα radiation. The microstructure morphology was characterized by the EVOMA 10 scanning electron microscopy (SEM). The electric conductivity test was carried out with 4-electrode system. The test of arc erosion adopts the self-designed arc erosion test system; this system can provide 30–60 A resistance alternating current; Density is measured by buoyancy method.

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Table 1
Particle size of copper powder.

Mean	46.46 μm
Median	44.99 μm
Mode	55.14 μm
Specific surf. area	4251 cm^2/mL

<10%	<25%	<50%	75%	<90%
16.68 μm	28.33 μm	44.99 μm	62.71 μm	79.41 μm

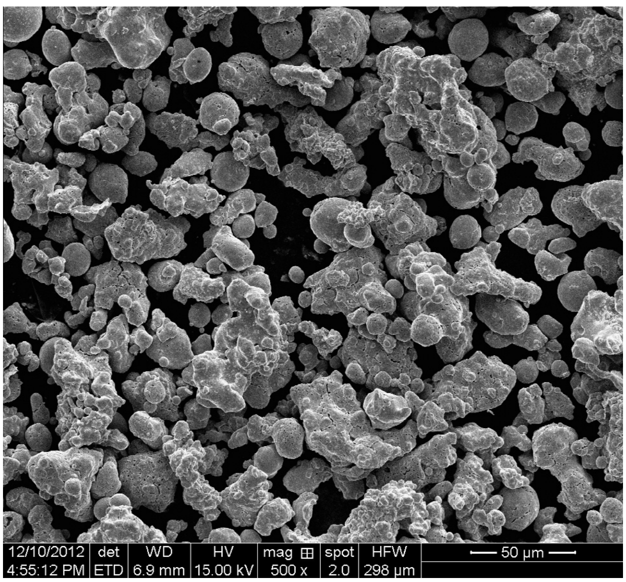

Fig. 1. SEM photos of copper powder.

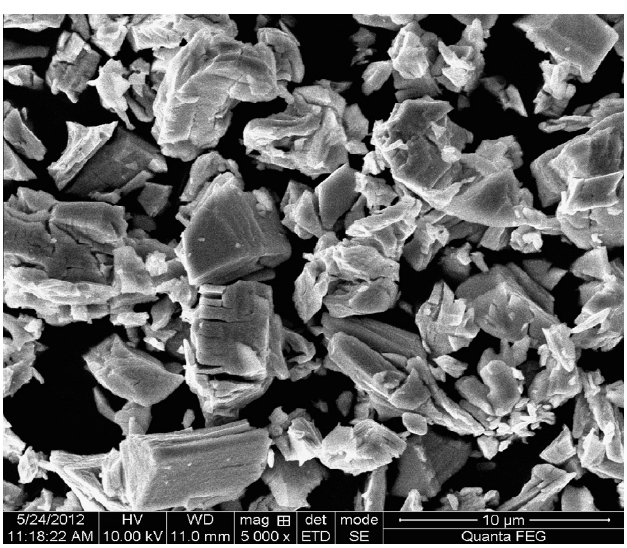

Fig. 2. SEM photos of Y_2O_3.

3. Results and discussion

3.1. Powder morphology

Fig. 1 shows the morphology of the copper powder. From Fig. 1, it can be seen that most copper powders are ball-shaped. The particle sizes of most Y_2O_3 powders are under 5 μm, irregular shape and some powders have deep cracks (Fig. 2). Because of its special structure, Y_2O_3 particles have larger surface area.

3.2. Effects of Y_2O_3 on the structure of samples

Fig. 3 shows that Y_2O_3 powders are evenly distributed in copper substrate. From Fig. 4 we can find that the spectral line of the sample containing Y_2O_3 shifts towards right compared to that of the sample without Y_2O_3. In general, the skewing of spectral line is caused by lattice distortion. Thus it is not difficult to find that adding Y_2O_3 causes lattice distortion of copper. Fig. 5 shows the metallographic structure of the samples, from which it is found

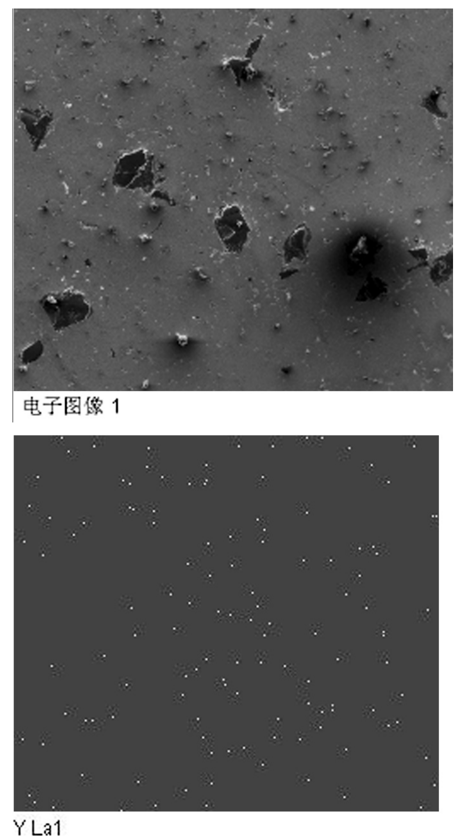

Fig. 3. Distribution of Y_2O_3 in matrix.

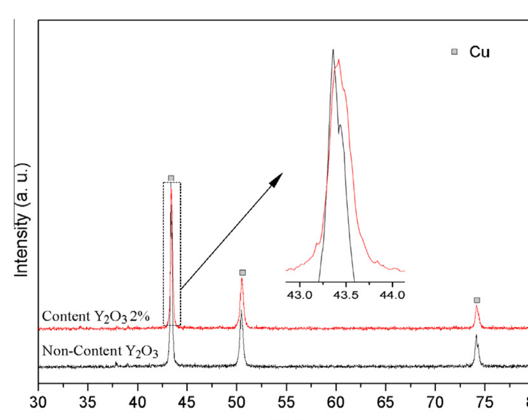

Fig. 4. X-ray diffraction result of samples content Y_2O_3 and non-content Y_2O_3.