Effect of Particle Size on the Microstructure of Cu60Cr40 Alloy by Microwave Sintering

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Abstract. Effect of the particle size of Cu, Cr on the microstructure of $Cu_{60}Cr_{40}$ alloys was investigated using the method of mechanical alloying and microwave sintering. The particle size of Cu, Cr was analysised by the BT-9300S type laser particle size distribution analyzer, and $Cu_{60}Cr_{40}$ alloys has been investigated by means of VEGA3SBH scanning electron microscopy. The results have shown that it was two normal distribution ranges in the particle size analysis of Cu, Cr , and the particle size decreased with the increasing milling time, which promoted the the peak of normal distribution moved to the right and increasesed. The microstructure of $Cu_{60}Cr_{40}$ alloys was changed to equiaxed grains which become homogeneous form fibrous, and the alloying of $Cu_{60}Cr_{40}$ alloy improved with the decrease of the particle size.

Introduction

Cu-Cr alloy combines the high hardness of Cr and the good conductivity of Cu, and it is widely used in the preparation of contact material, electrical switch, electric car and electric locomotive, etc. [1-4]. The Cu-Cr binary alloy phase diagram [5] showed that Cr is very low in Cu solid solubility and almost insoluble at 800K, and Cu smaller in Cr solid solubility. It is also difficult to dissolve even in the liquid phas due to the Cu Cr alloy system has great positive mixing heat. The solidification Cr is easy to produce the microsegregation and severe macrosegregation because of Cu and Cr insoluble.

The Cu-Cr alloy material is produced using mixed powder sintering method which according to a certain proportion of the particle size of Cu and Cr powder under the protection of the atmosphere fully mixed, pressing, then in a protective atmosphere hot pressing forming, in order to obtain a uniform microstructure and macro closed pores; but the dense material is difficult to guarantee resulting in the mechanical strength low.

The CuCr alloy is investigated by mechanical alloying and cold pressed powder by using microwave sintering of uniform heating of the alloy ideas in this paper. It is mainly to explore the mechanical alloying process and the Cu Cr alloy powder size of microwave sintering and the microstructure of the alloy studied in order to obtain excellent organizational structure.

Experiment method

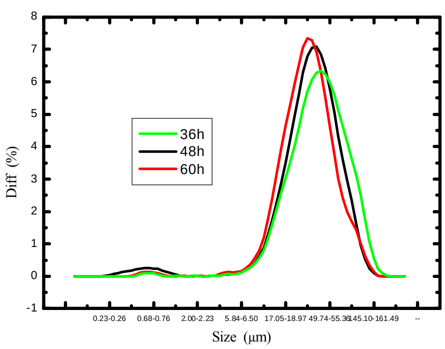
Alloy raw material were performed using copper and chromium powders. The experimental powder mixtures used during this work were obtained by combining 99.95% pure Cu and 99.9% Cr elemental powders with a particle size below 3 ~ 5 m and 74 m, respectively. According to Cu60Cr40 alloy chemical composition configuration alloy, alloy weight is about 5-10 g. In a typical run, copper powder was mixed with chromium (40 at.%), and the mixture was placed in a 25ml stainless steel container and milled in a QM-1SP type planetary high energy ball mill, with argon for 48h, 36h and 60h. Stainless steel balls of 8mm diameter using a constant balls/powder ratio of 10:1. The copper powder was mixed with chromium was placed in vacuum drying oven after grinding, vacuum to 2* 10^{-2}Pa, temperature

318K, drying 2~3h. The particle size of the copper powder was mixed with chromium was measured by BT-9300S laser particle size analyzer. The copper powder was mixed with chromium was cold pressured with using DNS100 universal testing machine in the mold and 30min. The cold pressing Cu60Cr40 alloy samples is placed in machine central loading platform of the MKX-T3-1 microwave sintering machine for sintering at the 3KW keeping 30min form 1KW to 3KW every 10 minutes plus 1KW. The Cu60Cr40 alloy samples sintered is cooled to room temperature then every 10min minus 1KW. The sintering temperature is temperatured by the U.S. production of two-color infrared temperature measurement instrument MRISBSF. The microstructure and phase components of the Cu60Cr40 alloy were analyzed by VEGA3SBH scanning electron microscope and the energy dispersive spectrometer.. X ray diffraction determination of powder samples by Cu-K target in X - ray diffraction spectrum, crystal structure analysis of samples.

Experimental results and discussion

The graph analysis is shown in Figure 1. The distribution of Cu, Cr powder particle size is similar to the trend from the figure shown 36h, 48h, and 60h grinding. It is appeared high and one low two into normal distribution of the wave in the particle size distribution figure. The first peak wave appeared in the 0~6.5m and content very low . The second peak appears in the 6.5~117.13m obtained and content very high. The peak point of 36h, 48h and 60 in tested are in the 40.15~44.69m, 32.41~36.07m and 26.16~29.12, respectively. The highest peak and minimum are 60h and 36h.The main peak is increased and move to the left and decreased the particle size of the powder of Cu, Cr in constant with the milling time increasing.

Figure 2 is Cu60Cr40 alloy grain size cumulative concentration distribution. From the figure can also be seen cumulative content curve of Cu, Cr powder particle size whole left changes with milling time measured increased, which indicating whole of Cu, Cr powder particle size distribution to lower and not an interval decreased with the milling time increasing.



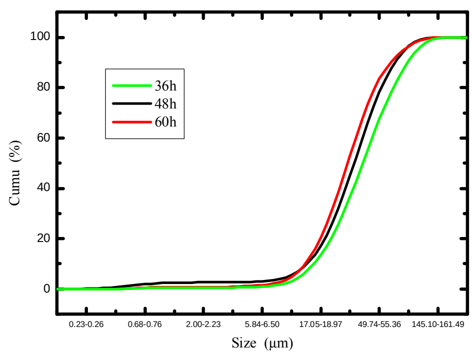


Fig.1 Particle size distribution of $Cu_{60}Cr_{40}$ alloy Fig.2 Particle size distribution in $Cu_{60}Cr_{40}$ alloy

The microstructure and the energy spectra of the $Cu_{60}Cr_{40}$ alloy were shown in figure 3 (a) ~ (c) and 3 (d) ~ (f) in 36h, 48h and 60h, respectively. The microstrucyure of $Cu_{60}Cr_{40}$ alloy is fibrous or strip in figure 3 (a). The red is rich Cr phase and the green is rich Cu phase in figure 3 (d). From microstructure figure can be seen, the microstructure showed equiaxed grains and rich in Cr and Cu rich phase distribution more uniform sintering produced smaller gaps at 60h. The microstructure of 36h and 48h was fibrous and the dendrite of 36h was shorter than that of 48h.

Table 1 The milling time corresponding to the phase composition of $Cu_{60}Cr_{40}$ alloy

Milling time(h)	Gray phase constituents (%)		Black phase constituents (%)	
	Cr	Cu	Cr	Cu
36	5.56	94.44	93.32	6.68
48	14.58	85.42	84.65	15.35
60	37.73	62.27	69.55	30.45

The microstructure compositions of $Cu_{60}Cr_{40}$ alloy which is gray phase A and blace phase B is shown table 1 for ball milling 36h, 48h and 60h Cu60Cr40. It is that the grey phase is Cu rich phase and dark grey phase is Cr rich phase by energy spectrum analysis, and the content of Cr in Cu rich phase is increasing with the milling time increasing. The same Cu content is also increasing in rich Cr phase. The color of Cu rich phase and Cr rich phase gradually close to the same at the milling time 60h, which the difference is smaller, and the microstructureis of Cu rich phase and Cr phase close to equiaxed grains.

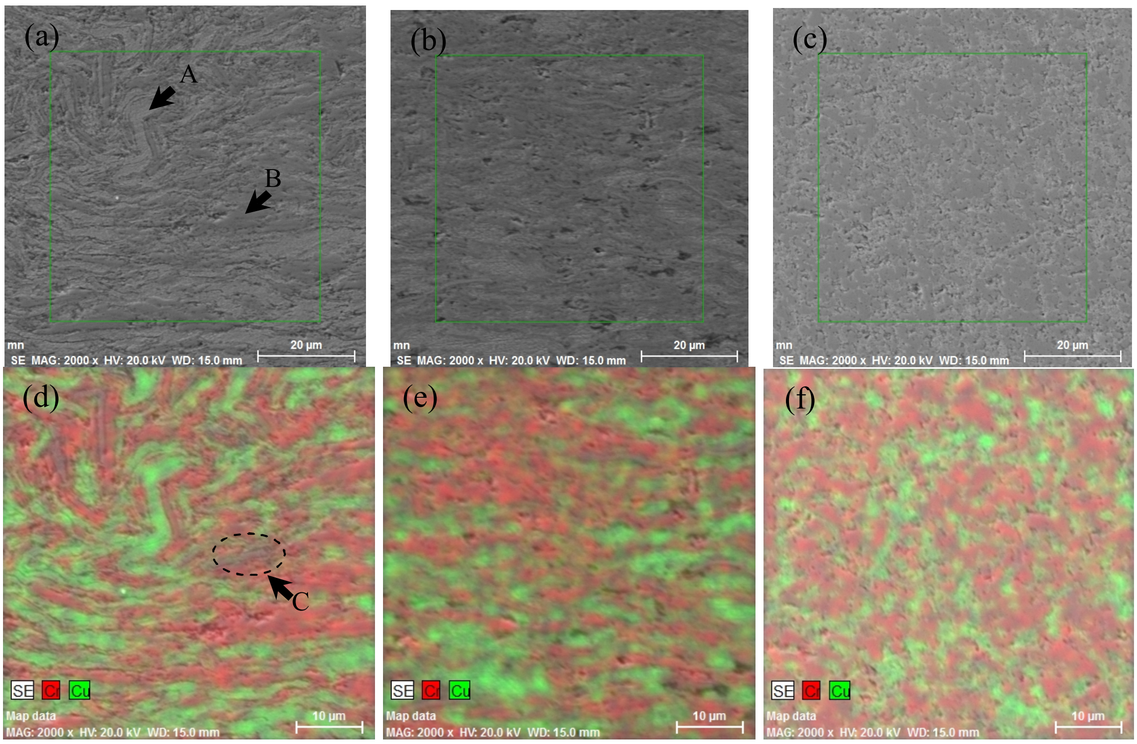


Fig.3 Microstructure of inducted $Cu_{60}Cr_{40}$ alloys (a)and (d) 48h (b) and (e) 60h (c) and (f) 72h

In summary, the power size of Cu and Cr gradually reduce with increasing the milling time, but decrease with time extended gradually reduced. It is shown that alloying of $Cu_{60}Cr_{40}$ alloy is promoted with the power size of Cu and Cr gradually reduce form the content of Cu and Cr in the microstructure.

The reasons should have two: (1) the dislocation and various kinds of crystal defects is increasing with particle size continuous refinement in the milling process of Cu and Cr powder. The strengthening the alloying [6~10] is due to high-energy ball mill of high-speed strengthened the deformation to fracture and cold welding process and promote the powder between diffusion and solid state reaction. (2) the $Cu_{60}Cr_{40}$ alloy is uniform heated to 1073K temperature by absorb microwave energy transformed to $Cu_{60}Cr_{40}$ alloy internal molecular kinetic energy and heat energy, which reduce the temperature gradient in the high temperature sintering process and effectively promote the densification of the $Cu_{60}Cr_{40}$ alloy and alloying.

Conclusion

The microstructure and structural of Cu60Cr40 alloy using microwave sintering were analyzed by using the particle size distribution analyzer and SEM, and the following conclusions were obtained:

(1) the granularity of Cu and Cr can be refined, and the alloying is promoted with the increase of the ball milling time of high energy ball mill;

(2) with the decrease of Cr and Cu powder granularity, the microstructure of microwave sintered $Cu_{60}Cr_{40}$ alloy gradually is transformed into the columnar grains, and the Cu and Cr components gradually converged in the rich Cu and Cr phases.

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