2006 POWDER METALLURGY
World Congress
PM2006

PB06-T-01

Preparation of TiB_2 Dispersed Cu Alloy by Spark Plasma Sintering

Kyong-Ju Kim[1,a], Gil-Geun Lee[2,b], and Ik-Min Park[3,c]

[1]Division of Materials Science and Engineering, Pukyong National University,
San 100, Yongdang-dong, Nam-Gu, Busan, 608-739, Korea
[2]Department of Materials Science and Engineering, Pusan National University,
Jangjeon 2-dong, Geumjeong-Gu, Busan, 609-735, Korea
[a]roughkkj@hanmail.net, [b]gglee@pknu.ac.kr, [c]impark@pusan.ac.kr

Abstract

The TiB_2 dispersion strengthened copper alloy was attracted as thermal and electrical functional material for the high mechanical strength, high thermal stability and good conductivity of TiB_2. In the present study, the focus is on the synthesis of TiB_2 dispersed copper alloy by spark plasma sintering process using copper oxide and titanium diboride as raw materials. The mechanical, thermal and electrical properties of sintered bodies were discussed with the sintering parameters, and developed microstructure and phase of sintered bodies.

Keywords : Dispersion reinforced alloy, Copper matrix composites, Titanium diboride, Spark plasma sintering

1. Introduction

Particle dispersion reinforced alloy has the effect that increase strain-hardening and yield strength by reinforcing phases, because the reinforcing phases have been the source to the generation of dislocation and obstruct movement of dislocation. Also, the reinforcing phases at elevated temperature have the advantage of enhancing high temperature creep properties by inhibiting movement of grain boundary. Dispersion reinforced copper alloy has been noticed as thermal/mechanical functional material (such as electric contact materials and semiconductor materials) for the high thermal stability, high mechanical strength, low electric resistance, and good conductivity.

Generally, dispersion particle has been selected as high mechanical strength, high melting temperature, low thermal expansion coefficient, and low solubility within metal matrix, such as metals, carbides, oxides, and borides. There are Cu-Al_2O_3 alloy, Cu-Nb alloy, Cu-WC alloy, and Cu-Fe_2O_3 alloy as copper matrix composites which these dispersion particles are composed. Mainly the studies on effect of dispersion phases have been reported.[1-3] The copper matrix composites have problems to deterioration of electric properties, segregations of dispersion phases by interface properties between dispersion phases and matrix. These problems can be solved by using TiB_2 which has high melting temperature (3225^{o}C), high hardness (3400kg/mm^2), low electric resistance ($0.03\times 10^{-5}\Omega$m) and high thermal conductivity (66W/mK).

To manufacture high quality of dispersion strengthened metal composites, but also the interface between dispersion particle and matrix needs to be controlled not only the dispersion particle with an ultrafine particle size should be homogenously dispersed. A number of processes exit for synthesizing TiB_2 dispersed copper alloy, such as casting, internal oxidation, spray-forming, amongst other. However, the casting is difficult to manufacture ultrafine dispersion particle. Due to the presence of impurities, most of materials properties as internal oxidation have the problem to deteriorate, and it is difficult to perform processing. TiB_2 fabricated by spray forming has been studies for micro sized, not nano sized.

Recently, spark plasma sintering process (SPS) was spotlighted due to the lower sintering temperature and shorter time than other conventional sintering processes.

In the present study, the focus is on the synthesis of TiB_2 dispersed copper alloy by spark plasma sintering process. The powder mixtures of TiB_2 and CuO were prepared by the mechanical milling process and plasma arc discharge process. The changed mechanical, thermal and electrical properties of sintered bodies were discussed with the mixture preparation process, and developed microstructure and phase of sintered bodies.

2. Experimental and Results

The raw powders CuO (purity of 99+% and particle size <5 μ m), and TiB_2 (purity of 99+% and particle size <3 μ m) were weighted to obtain the targets compositions of Cu-1vol%TiB_2, Cu-3vol%TiB_2, and Cu-5vol%TiB_2.

The mechanical milling was performed under an argon atmosphere for 24hours using a high-energy ball mill with rotating speed 500rpm. Subsequently, the mixture was heat treated at 400^{o}C for 1hour in a tube furnace a flowing stream of hydrogen atmosphere.

Figure 1 shows the X-ray diffraction patterns of the

© Korean Powder Metallurgy Institute

mechanical milled mixture powder and reduced powder. The diffraction pattern of the mechanical milled powder shows CuO phase, and can not shows TiB_2 phase. The reduced powder has only the diffraction pattern of the copper phase. In knows that the mixture powder of CuO/TiB_2 was changed to the Cu/TiB_2 composite powder by the reduction process.

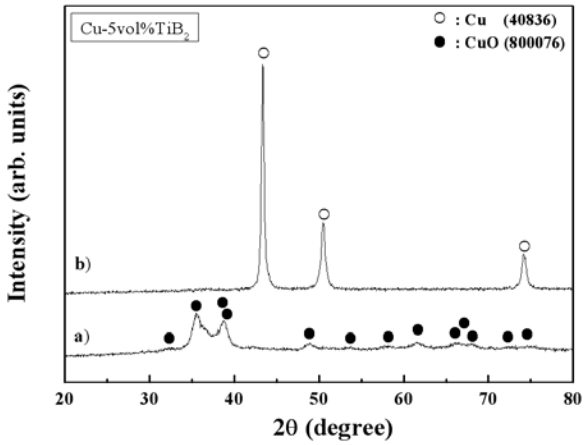

Fig. 1. X-ray diffraction patterns of (a) mechanical milled powder and (b) reduced powder.

Figure 2 shows the Field Emission SEM micrographs of reduced Cu and Cu-5vol%TiB_2 powders. These powders agglomerated with submicrosized particles. The reduced powders were sintered by spark plasma sintering under a vacuum. The applied pressure and temperature were 60MPa and 600~800°C, respectively.

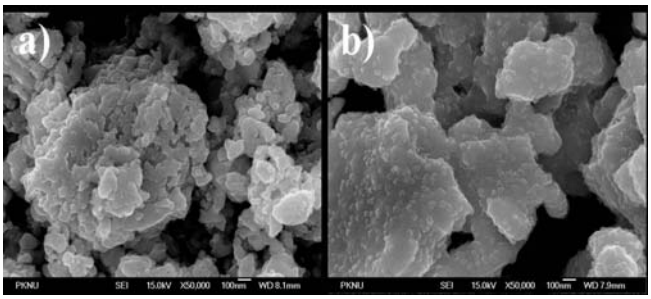

Fig. 2. FE-SEM micrographs of the reduced powders of (a) Cu and (b) Cu-5vol%TiB_2.

Figure 3 shows the change of the relative density of the sintered body with sintering temperature. The density of the sintered body increase with increasing sintering temperature, and decrease with increasing the volume fraction of TiB_2.

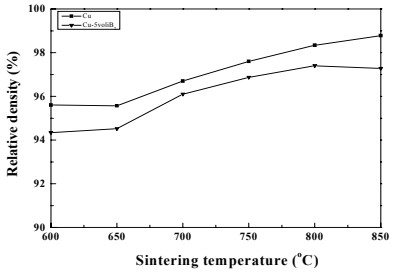

Fig. 3. The change of relative density of sintered body with sintering temperature for various TiB_2 contents.

Figure 4 shows the hardness of the pure copper increase with increasing sintering temperature until at 800°C, and decrease at sintering temperature of 850°C. However, the hardness of the TiB_2 dispersed copper alloy continuously decreases with increasing sintering temperature until at 850°C.

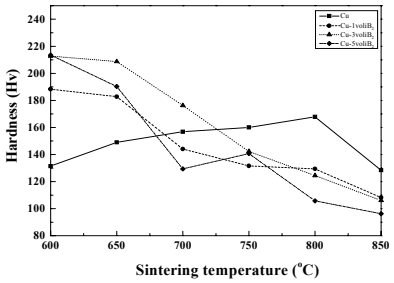

Fig. 4. The change of the hardness of the sintered body with sintering temperature for various TiB_2 contents.

3. Summary

The TiB_2 dispersed copper alloy can be prepared by spark plasma sintering process using copper oxide and titanium diboride as raw materials. The density of the TiB_2 dispersed copper alloy increase with increasing sintering temperature. However, the hardness of the one decreased with increasing sintering temperature.

4. References

1. S. Liang, L. Fang and Z. Fan, Mater. Sci. Enang, A., 374, 27 (2004).
2. S. I. Hong and M. A. Hill, Scripta Mater., 44, 2509 (2001).
3. J. S. Lee, N. J. Kim, J .Y. Jung, E. S. Lee and S. A., Scripta Materialia, 39(8), 1063 (1998).

© Korean Powder Metallurgy Institute