Enhancement of Microstructural Homogeneity of W-Cu Pseudo-alloy by Adding W-Cu Composite Powder in Infiltration Process

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Abstract

An infiltration technique using W-Cu composite powder has been developed to enhance microstructural uniformity of W-Cu pseudo-alloy. W-Cu composite powder, manufactured by reduction from WO_3 and CuO powder mixtures, were blended with W powder and then cold iso-statically pressed into a cylindrical bar under 150 MPa. The pressed samples were pre-sintered at 1300 °C for 1 hour under hydrogen to make a skeleton structure. This skeleton structure was more homogeneous than that formed by using W and Cu powder mixtures. The skeleton structures were infiltrated with Cu under hydrogen atmosphere. The infiltrated W-Cu pseudo-alloy showed homogeneous microstructure without Cu rich region

Keywords : W-Cu pseudo-alloy, W-Cu composite powder, Infiltration

1. Introduction

W-Cu pseudo-alloy possesses potential for applications such as a contact of high power electricity and heat sink of micro-electronic package because of its high electrical and thermal conductivities and low thermal expansion coefficient [1]. Moreover, W-Cu pseudo-alloy has been focused as one of promising materials for a shaped charge liner in military field, due to its high density and excellent elongation in high strain rate [2].

However, it is hard to manufacture W-Cu pseudo-alloy with homogeneous microstructure by conventional liquid phase sintering, because densification is disturbed by the limited solubility of W in liquid Cu [3]. On the other hand, infiltration method[4], where Cu melt is impregnated into W skeleton with porosity level ranging from 50 to 20 volume percent, is very useful alternative. In this case, the chemical composition of W-Cu pseudo-alloy is around 75W-25Cu to 90W-10Cu in weight percent. Therefore, in order to obtain W-Cu pseudo-alloy with higher Cu content, for instance 60W-40Cu or 50W-50Cu in weight percent, an appropriate amount of Cu powder has to be added into W powder before making a skeleton structure. Preliminarily added Cu plays significant roles to give skeleton structure strength and to assist infiltration process by smoothing capillaries: however, it leaves Cu rich region called Cu pool.

In the present work, a new infiltration process that can fabricate W-Cu pseudo-alloy with homogeneous microstructure, i.e., without Cu pool has been developed. For this purpose, W-Cu composite powder made by co-reduction treatment from W and Cu oxide powders is blended with W powder instead of Cu powder. To investigate the effect of this technique on microstructure of W-Cu pseudo-alloy, scanning electron microscopic examination has been carried out before and after infiltration process.

2. Experimental and Results

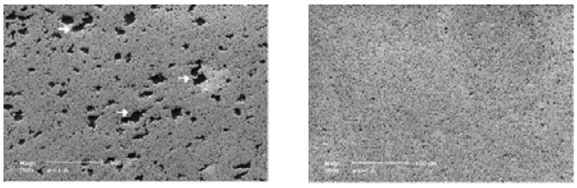
Tungsten powders with average particle sizes of 2.0 and 4.5 μm, respectively, and W-Cu composite powder made by reduction from WO_3 and CuO powder mixtures were weighed for W to Cu ratio to be 8 to 1 and 12 to 1 in weight percent. Powders were blended in a turbular mixer for 8 hours, and then cold iso-statically pressed (CIP) into a cylindrical bar (30 mm diameter x 20 mm height) under 150 MPa. The pressed compacts are pre-sintered at 1300°C for 1 hour under flowing hydrogen gas with a dew point temperature of -60°C to make a skeleton structure.

After pre-sintering, W skeleton was contacted with Cu scraps, and infiltration process was carried out by heating up to 1250°C with heating rate of 10°C per minute and holding for 1 hour under hydrogen atmosphere. The micro-structures of W skeleton and infiltrated W-Cu pseudo-alloy were observed with Philips XL300 scanning electron microscope (SEM)

Fig. 1 (a) and (b) show microstructure of W-Cu pseudo-alloys after infiltrating Cu into skeleton structures. W-Cu pseudo alloy fabricated from W and Cu powder mixtures reveals Cu rich region (Cu pool) in Fig. 1 (a). Fig. 1 (a) showa that the morphology of Cu pool is very similar to that of pores in skeleton structure. This implies that the pores play an important role in the formation of Cu pool, which is consequently replaced with Cu melt during infiltration process.

On the contrary, W-Cu pseudo-alloy made from W and

W-Cu powder mixtures does not show Cu pool, but homogeneous microstructure, as shown in Fig. 1 (b). This also indicates that the use of W-Cu composite powder instead of Cu powder can be very useful to obtain W-Cu pseudo-alloy with homogeneous microstructure



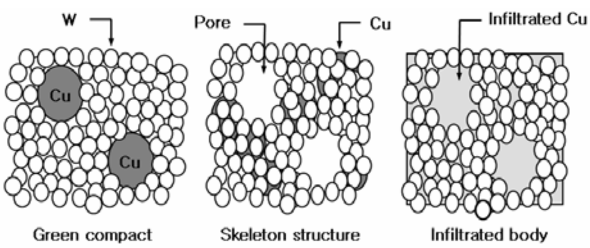
(a) (b)

Fig. 1. Scanning electron micrographs of the infiltrated W-Cu pseudo-alloy made by using (a) W and Cu powder and (b) W and W-Cu composite powder mixtures. Particle size of the W used is about 2.0 μm

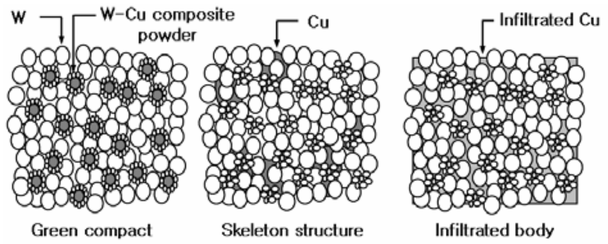
In order to investigate whether the addition of W-Cu composite powder is still effective even in larger W particle size, W-Cu pseudo-alloy was fabricated by using W powder with an average particle size of 4.5 μm instead of 2.0 μm. These microstructural changes are basically the same as those observed in Fig. 1.

Fig. 2 (a) and (b) are schematic diagrams to explain phenomen that are observed during sintering and infiltration processes in W and Cu and in W and W-Cu composite powder mixtures, respectively. In the case of W and Cu powder mixture, during sintering process Cu melt moves out to the sites between W particles with relatively narrow gap, because the capillary force is inversely proportional to the gap. Accordingly, the sites preliminarily occupied by Cu powders are changed into large pores. During infiltration process, the pores and un-filled regions are impregnated with externally supplied Cu melt. In this case, the final microstructure of W-Cu pseudo-alloy reveals inhomogenity as observed in Fig. 1 (a).

On the contrary, when W and W-Cu composite powder mixtures are used, W particles contained in W-Cu composite powders remain in original positions, although Cu melt moves out. Thus, there is no chance to form large pores during sintering process and, thereby, the homogeneous microstructure can be obtained from infiltration process, as shown in Fig. 2 (a).



(a)



(b)

Fig. 2. Schematic diagram showing the sintering and infiltration procsses of (a) W and Cu powder and (b) W and W-Cu composite powder mixtures.

3. Summary

An infiltration technique using W-Cu composite powder has been developed to manufacture W-Cu pseudo-alloy with homogeneous microstructure, i.e., without Cu rich region. Tungsten powder and W-Cu composite powder which was manufactured by reduction from WO_3 and CuO powder mixture, were mixed together, cold iso-statically pressed (CIP) into a cylindrical bar, and then sintered to make skeleton structure. During sintering process, W particles contained in the W-Cu composite powder prevented the formation of large pores in the skeleton structure. The skeleton structure was infiltrated by Cu to manufacture W-Cu pseudo-alloy. The infiltrated W-Cu pseudo- alloy showed homogeneous microstructure without Cu rich region. It appears that the developed technique provides an easy method of infiltration without the formation of Cu rich region. Further improvements of life cycle of electric contact and penetration performance of shaped charge liner could be expected by homogeneous microstructure.

4. References

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