Consolidation of Cu54Ni6Zr22Ti18 Bulk Metallic Glass Powders

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Bulk metallic glasses (BMG) are known as a candidate for a future industrial application with a great potential, corresponding to their quite a high room-temperature-strength near 2GPa as well as an excellent corrosion resistance. Cu based BMG stands on the center of investigation due to its low cost and high strength rather than those in other based BMG such as Al, Zr, Ni, etc. However, a relatively low glass forming ability of the BMGs obtained by a casting process has limits their industrial applications, so that powder metallurgy process (PM) was proposed as an alternative to overcome the problem, because the final size of powder is less than 1 mm at least. An advance in the powder processing technology also promotes the industrialization of Cu based BMG using the PM. In this work, spark plasma sintering process (SPS) was used to consolidate the $Cu_{54}Ni_6Zr_{22}Ti_{18}$ BMG powder prepared by a gas atomization. SPS is suitable for consolidating the BMG powders due to its characteristics such as a rapid and uniform reaction, sintering with little additives, low running cost and easy operation.

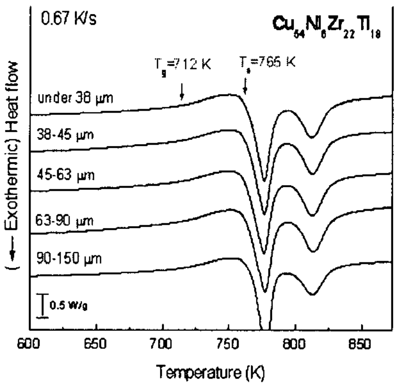

Fig. 4 DSC traces of $Cu_{54}Ni_6Zr_{22}Ti_{18}$ powders with the powder sizes

$Cu_{54}Ni_6Zr_{22}Ti_{18}$	T_g (K)	T_x (K)	ΔH (J/g)	ΔT (K)
Powder	712	767	66.5	55
Ribbon	712	769	66.4	57
Thin Plate	714	767	65.1	53
Rod(6mm)	714	765	63.2	51

Table 1. Thermal behavior of BMGs with processes.

Looking at the experimental results, spherical $Cu_{54}Ni_6Zr_{22}Ti_{18}$ bulk metallic glass (BMG) powders were prepared using a high pressure gas atomizer. The glass forming ability of both powders as atomized and bulks as SPSed was investigated by X-ray diffractometer (XRD) and differential scanning calorimeter (DSC) as a function of powder size distribution (Fig. 1). The glass forming ability is similar until 150 μm in diameter.

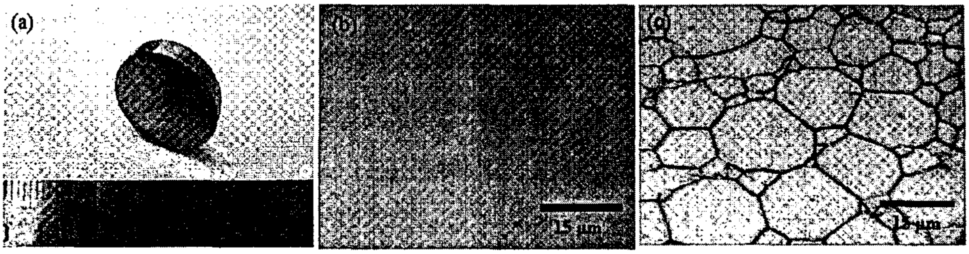

Fig. 2 Photograph (a) and optical micrographs of SPSed bulk before (b) and after (c) chemical etching

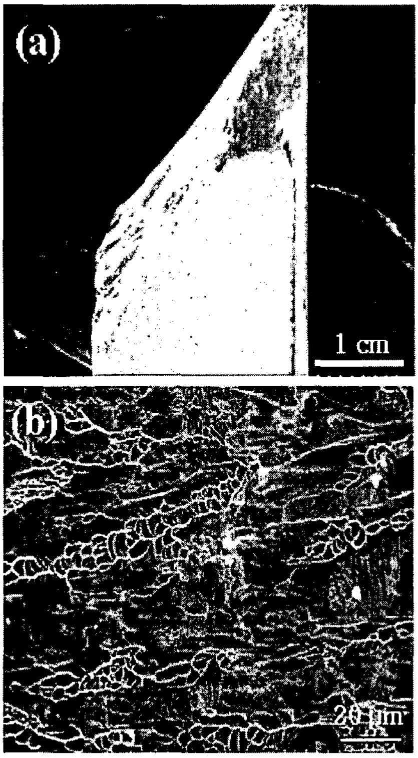

Fig. 3 Fracture patterns of bulk specimen compression tested.

Table 1 lists the thermal behavior of the BMGs with the processes, in which the thermal behavior was almost similar between the process. The temperatures for glass transition (T_g), and crystallization (T_x), crystallization enthalpy($\triangle H$), supercooled liquid region ($\triangle T_x$ = T_x - T_g) of the powder were 712K, 767K, 66.5J/g and 55K. The SPSed bulk maintains the amorphous structure, but the $\triangle T_x$ was slightly lower. Fig. 2 shows a photograph (a) and optical micrographs of SPSed bulk before (b) and after (c) the chemical etching. It presents a sound consolidation without any noticeable pores (b) and a good and homogeneous microstructures (c). The compressive strength was increased as the powder size increased due to an easy plastic deformation at the coarse powders.

Typical self-sharpening effect of BMG was happened in the consolidated bulk during the compression test, which was determined from the fracture occurred along the maximum shear plane declined ~45° to the loading direction (Fig. 3).