

Ni–Zr–Ti–Si–Sn/Cu metallic glass composites prepared by magnetic compaction

J.-H. Ahn^{a,*}, Y.J. Kim^b, B.K. Kim^b

^a Department of Materials Engineering, Andong National University, 388 Sonchun-dong, Andong, Gyungbuk 760–749, Korea

^b Center for Powder Materials, Korea Institute of Machinery and Materials, 66 Sangnam-dong, Gyungnam 641–010, Korea

Received 12 October 2005; accepted 26 March 2006

Available online 2 May 2006

Abstract

Ni–Zr–Ti–Si–Sn/Cu metallic glass (BMG) composites were fabricated by magnetic compaction of powder mixtures. A considerable plastic deformation took place without apparent failure during the dynamic compaction even at room temperature and at a high strain rate. The BMG particles retained their amorphous phase after the dynamic magnetic compaction at 450 °C. The resulting Ni_{52.65}Zr_{28.71}Ti_{13.57}Si_{1.33}Sn_{3.74}/60% Cu composite exhibited a remarkable tensile ductility at room temperature combined with high strength: tensile elongation of 28% and ultimate tensile stress up to 1.1 GPa.

© 2006 Elsevier B.V. All rights reserved.

Keywords: Powder technology; Composite materials; Bulk metallic glass

1. Introduction

Bulk metallic glasses (BMGs) have attracted considerable attention due to their unique properties such as high strength and high elastic modulus [1,2]. However, one of major drawbacks of BMGs is their low plasticity at room temperature. This has limited wide application of BMGs to novel engineering alloys [3–6]. The poor ductility of BMGs is attributed to their unique behaviour of plastic deformation which is usually confined to highly localized regions near shear bands, resulting in catastrophic failure without apparent plasticity. The ductility of BMGs is thought to be improved by encouraging the number of multiple shear bands and/or deflecting crack propagation.

Various attempts have been made for this purpose: e.g., the dispersion of nanocrystallites by partial devitrification via thermal annealing [7,8], the addition of micron-sized crystalline particles prior to casting [9,10], and the preparation of composite alloys with hard or soft phases [11–18]. Among them, BMG composites with ductile crystalline phases have demonstrated a dramatic improvement in ductility. In particular,

the fabrication of metallic glass matrix composites (MGMs) via warm consolidation process has appeared one attractive method in terms of controlling bulk size limitation and mechanical properties. Such composites exhibited enhanced plasticity and improved impact toughness compared to monolithic BMGs. Many investigations have reported improved compressive plastic strain in BMGs by formulating composite structures. However, their tensile ductility is still insufficient to be employed as useful engineering alloys for various structural applications.

In the present work, we have employed dynamic magnetic compaction (DMC) to fabricate BMG composites. The magnetic compaction is a novel consolidation process for metallic and ceramic powders to achieve nearly full-density during a short duration [19,20]. In this process, the powder is loaded into an electrically conductive metallic container, which is placed at the center of an electromagnetic coil. High magnetic pressure is created radially around the metallic container when a current pulse is applied to the surrounding coil. The powder is rapidly compressed by contraction of the container. Considering that dynamic magnetic compaction is very fast, the process is thought to be suitable for consolidating metastable powders such as amorphous or nanocrystalline alloys. In the present work, therefore, we have

* Corresponding author. Tel.: +82 54 820 5648; fax: +82 54 820 6126.

E-mail address: jhahn@andong.ac.kr (J.-H. Ahn).

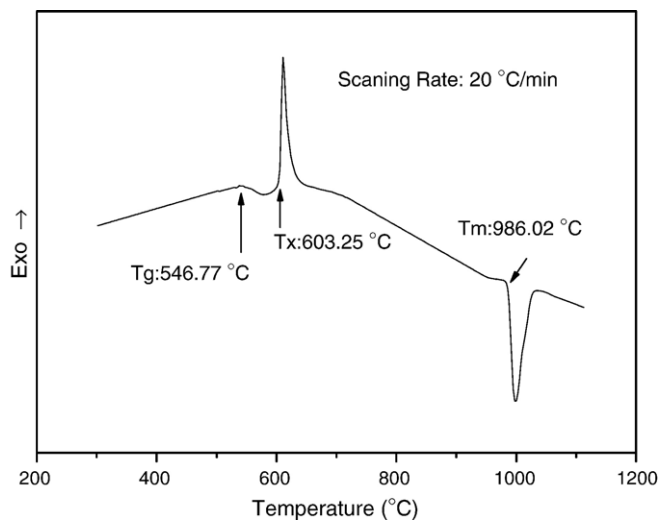


Fig. 1. DTA trace of the starting $\text{Ni}_{52.65}\text{Zr}_{28.71}\text{Ti}_{13.57}\text{Si}_{1.33}\text{Sn}_{3.74}$ BMG powder.

attempted this technique to consolidate BMG powders to make composites with ductile Cu powders. We have examined the densification, the retention of amorphous phase during magnetic compaction at warm temperatures and resulting mechanical properties.

2. Experimental procedures

$\text{Ni}_{52.65}\text{Zr}_{28.71}\text{Ti}_{13.57}\text{Si}_{1.33}\text{Sn}_{3.74}$ amorphous powder with spherical morphology has been prepared by gas atomization using a helium gas. The sieved amorphous $\text{Ni}_{52.65}\text{Zr}_{28.71}\text{Ti}_{13.57}$ -

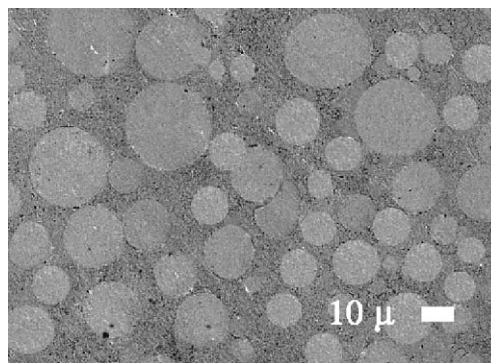


Fig. 3. Microstructure of $\text{Ni}_{52.65}\text{Zr}_{28.71}\text{Ti}_{13.57}\text{Si}_{1.33}\text{Sn}_{3.74}/60\%$ Cu composite after magnetic compaction at 450 °C.

$\text{Si}_{1.33}\text{Sn}_{3.74}$ powder (–325 mesh) were mixed with Cu powders in an argon-filled vial using light ball milling for an hour. Prior to the mixing, the Cu powder (–325 mesh in the form of sponge agglomerate, >99.99% purity) was purified in a hydrogen atmosphere at 300 °C for an hour to remove surface oxides. The mixing ratio of 0 and 60 wt.% Cu was used for the present work. Following the mixing of the BMG with Cu powder, a dynamic magnetic compaction was carried out without use of binders. The composite powder mixture was loaded into a copper cylinder (OD:70 mm, ID:60 mm, height:120 mm) which served as an electrically conductive metallic container. The powder-loaded container was placed at the center of an electromagnetic coil. High voltage (15 kV) was then applied to the coil for a very short duration of 20 ms. A current pulse applied to the coil created high magnetic pressure radially around the copper

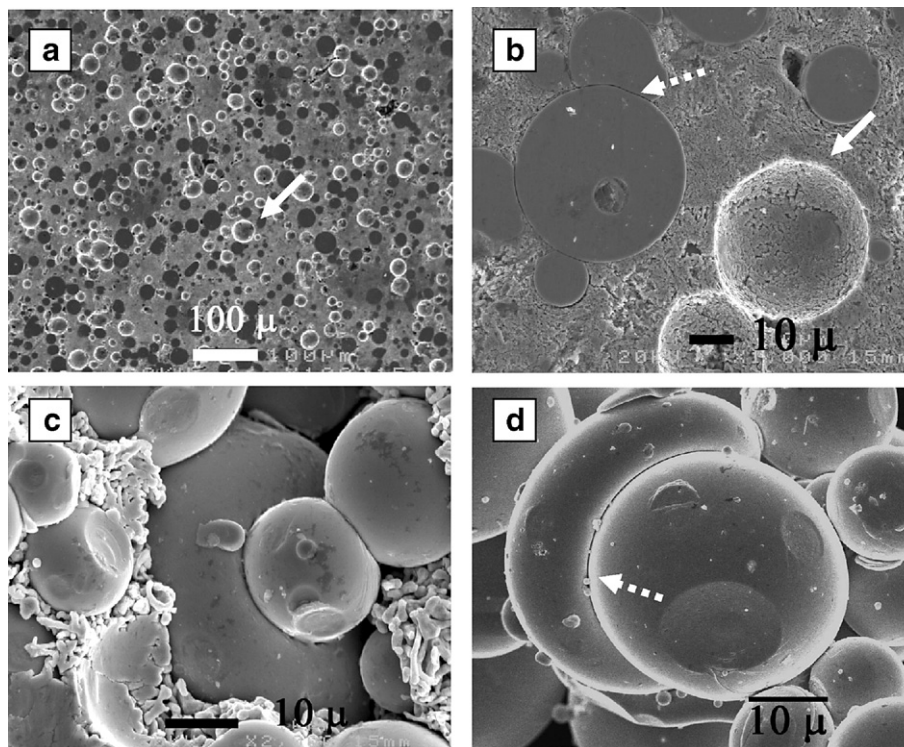


Fig. 2. Microstructures after magnetic compacted at room temperature. (a) and (b): $\text{Ni}_{52.65}\text{Zr}_{28.71}\text{Ti}_{13.57}\text{Si}_{1.33}\text{Sn}_{3.74}/60\%$ Cu, (c): $\text{Ni}_{52.65}\text{Zr}_{28.71}\text{Ti}_{13.57}\text{Si}_{1.33}\text{Sn}_{3.74}/10\%$ Cu, and (d): $\text{Ni}_{52.65}\text{Zr}_{28.71}\text{Ti}_{13.57}\text{Si}_{1.33}\text{Sn}_{3.74}$ (0% Cu).

Download English Version:

<https://daneshyari.com/en/article/1653429>

Download Persian Version:

<https://daneshyari.com/article/1653429>

[Daneshyari.com](https://daneshyari.com)