Available online at www.sciencedirect.com

Scripta Materialia 52 (2005) 945–949

www.actamat-journals.com

Rotation mechanism of shear fracture induced by high plasticity in Ti-based nano-structured composites containing ductile dendrites

Z.F. Zhang [a,*], G. He [b], H. Zhang [a], J. Eckert [c]

[a] *Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences, 72 Wenhua Road, Shenhe District, Shenyang 110016, China*

[b] *Light Materials Group, National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan*

[c] *Physical Metallurgy Division, Department of Materials and Geo Sciences, Darmstadt University of Technology, Petersenstr. 23, D-64287 Darmstadt, Germany*

Received 12 October 2004; received in revised form 9 December 2004; accepted 9 December 2004

Abstract

Ti-based nano-structured composites with ductile dendrites often fail under a shear fracture angle larger than 45° with the compression stress axis. This can be explained by a rotation mechanism of the shear plane and bending of the shear bands, indicating a good mechanical performance of the nano-structured composites.

© 2004 Acta Materialia Inc. Published by Elsevier Ltd. All rights reserved.

Keywords: Ti-based composite; Dendrite; Shear band; Rotation mechanism

1. Introduction

Bulk metallic glassy (BMG) materials have become a hot topic in the field of advanced materials due to the milestone discovery of Zr-based BMGs [1,2]. However, BMGs only exhibit high strength but, unfortunately, nearly zero plasticity, limiting their application as structural materials [3,4]. Recently, a major breakthrough in enhancing plasticity was achieved for BMG/nano-structured composites containing *in situ* precipitated dendritic phases upon solidification in Zr- and Ti-based alloys [5–10]. This improvement in plastic deformation is due to the strong blocking effect of the dendrites on the propagation of shear bands [5]. Normally, the shear band pattern formation into regular arrays was controlled by the ductile dendrites [5–8]. This opens the possibility of producing an entirely new class of high strength, tough, impact and fatigue resistant materials, which combine the high strength of metallic glass with the ability to undergo plastic deformation under unconfined or otherwise unstable loading conditions [5]. Furthermore, there is the possibility of employing the newly developed BMG/nano-structured composites in many potential applications, such as biomaterials [10]. However, the basic deformation, fracture mechanisms and the high plasticity of the nano-structured Ti-based composites with ductile dendrites have not been systematically investigated so far. The main subject of the present paper is to reveal the details of the deformation and fracture mechanisms, and the plasticity under compressive loading, in order to better understand the properties of the newly developed nano-structured Ti-based composites [7–10].

2. Experimental procedures

The nano-structured matrix–dendrite composites, $(Ti_{40}Cu_{28}Ni_{24}Sn_8)_{1-x}$ $(Ti_{80}Nb_{20})_x$, where x is equal to

---

[*] Corresponding author. Tel.: +86 24 23971043; fax: +86 24 23891320.
E-mail address: zhfzhang@imr.ac.cn (Z.F. Zhang).

1359-6462/$ - see front matter © 2004 Acta Materialia Inc. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.scriptamat.2004.12.014

Table 1
Compositions and shear fracture angles of the alloys A, B, C and D

Compositions of samples	Plastic strain (ε_P) (%)	Shear angle (θ_C^F) (°)	Shear angle (θ_C^0) (°)	($\theta_C^F - \theta_C^0$) (°)
A: $Ti_{56}Cu_{16.8}Ni_{14.4}Sn_{4.8}Nb_8$	8.9	46	43.5	2.5
B: $Ti_{60}Cu_{14}Ni_{12}Sn_4Nb_{10}$	21	48	41.4	6.6
C: $Ti_{64}Cu_{11.2}Ni_{9.6}Sn_{3.2}Nb_{12}$	24	50	41.9	8.1
D: $Ti_{66}Cu_8Ni_{4.8}Sn_{7.2}Nb_{14}$	30	51	40.5	10.5

0.4, 0.5 and 0.6, were fabricated by arc-melting. In addition, an alloy with an approximate composition of $Ti_{66}Cu_8Ni_{4.8}Sn_{7.2}Nb_{14}$ was selected. The compositions of the four alloys are listed in Table 1 and will be hereafter named as A, B, C and D alloys, respectively. The details of the fabrication processes of the nano-structured Ti-based composites have already been described elsewhere [9]. The characterization of the microstructure and the phases was done using a JEOL-JSM6400 scanning electron microscope (SEM). It was found that alloy A contains a relatively fine dendritic phase with a volume fraction of about 20%. For alloys B and C, the volume fractions of the dendrites are about 40% and 60%, respectively. Alloy D consists almost only of dendrites (about 95 vol.%) [9]. Normally, the distributions of the dendrites and the matrix are basically homogenous in the center of the samples. However, near the two surface layers of the samples, the dendrites are relatively fine in comparison with the other parts of the samples. Therefore, all the compressive specimens were cut into a dimension of 3 mm × 3 mm × 6 mm from the middle parts of the alloys. Before the tests, they were mechanically polished, and then polished either by chemical or electrolytic methods. The compression tests were conducted with an Instron 8562 testing machine at room temperature under quasi-static loading conditions (strain rate of $10^{-4}\ s^{-1}$). After deformation or failure, all the specimens were investigated by SEM to reveal the deformation and fracture features.

3. Results and discussion

Fig. 1(a)–(d) show the compressive stress–strain curves and fracture morphologies of the alloys A–D. The four Ti-based alloys display typical initial elastic

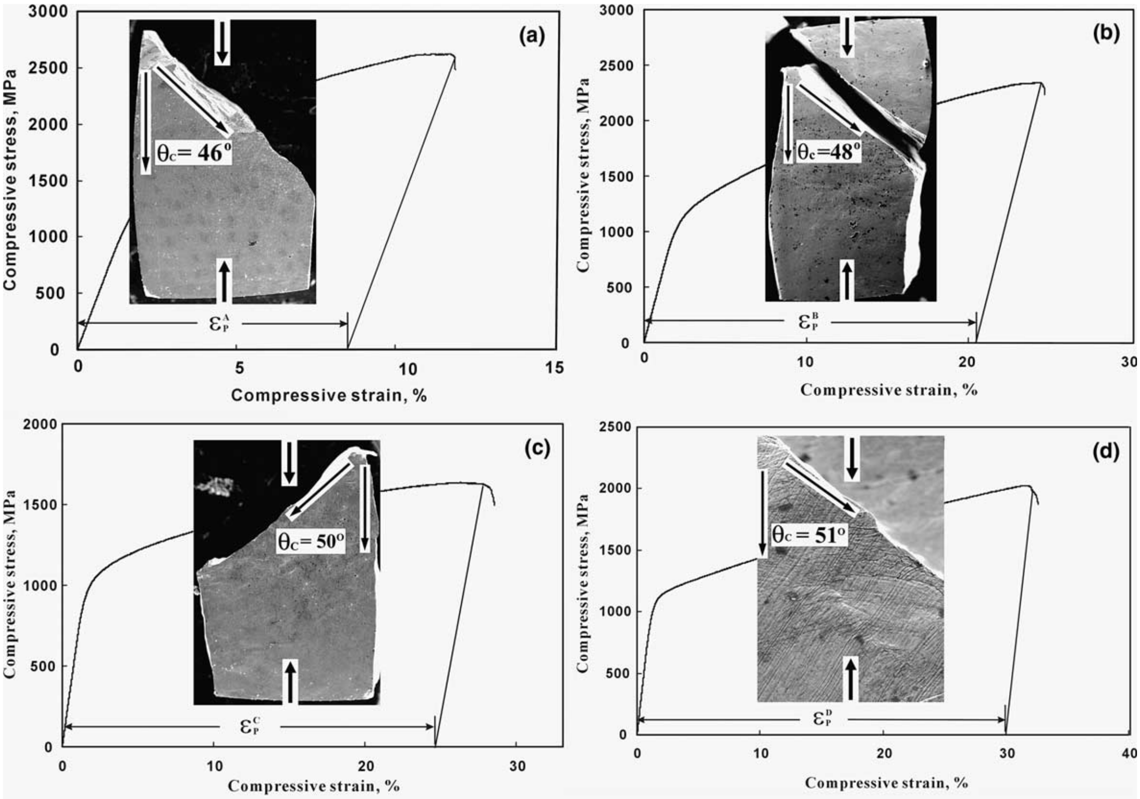

Fig. 1. Compressive stress-strain curves, fracture morphologies and shear fracture angles of the alloys A-D (a) alloy A; (b) alloy B; (c) alloy C and (d) alloy D.

Download English Version:

https://daneshyari.com/en/article/10634952

Download Persian Version:

https://daneshyari.com/article/10634952

Daneshyari.com