Intermetallics 17 (2009) 1115–1119

Contents lists available at ScienceDirect

Intermetallics

journal homepage: www.elsevier.com/locate/intermet

Short communication

Microstructure evolution and mechanical properties' improvement of NiAl–Cr(Mo)–Hf eutectic alloy during suction casting and subsequent HIP treatment

L.Y. Sheng [a,b,*], W. Zhang [b], J.T. Guo [b], L.Z. Zhou [b], H.Q. Ye [b]

[a] Institute of Industry Technology, Guangzhou & Chinese Academy of Sciences, Guangzhou 511458, China
[b] Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China

ARTICLE INFO

Article history:
Received 3 December 2008
Received in revised form
23 April 2009
Accepted 14 May 2009
Available online 17 June 2009

Keywords:
A. Nickel aluminides, based on NiAl
B. Mechanical properties at ambient temperature
B. Mechanical properties at high temperatures
C. Rapid solidification processing
C. Hot isostatic pressing

ABSTRACT

A NiAl–Cr(Mo)–Hf eutectic alloy was prepared by suction-casting technique and subsequently hot isostatic pressing treatment. Microstructure and mechanical tests were performed and the results revealed that the suction-cast alloy possessed fine NiAl/Cr(Mo) lamellar, large area fraction of eutectic cell and semi-continuously distributed Ni_2AlHf phase at the cell boundaries. After the HIP treatment, the Ni_2AlHf particles became fine and distributed evenly in the alloy. Moreover, some of the Ni_2AlHf particles along the eutectic cell boundaries were transformed into Hf solid solution phase. Compared with the conventionally cast alloy, the room-temperature compressive ductility and strength of the suction-cast alloy attained significant improvement. In addition, the room-temperature ductility and elevated temperature strength of suction-cast alloy were markedly enhanced by HIP treatment.

1. Introduction

NiAl has received much attention as a potential high-temperature structural material because of its many advantages, but its poor high-temperature strength and low room-temperature ductility and fracture toughness limit its industry applications [1,2]. In order to conquer these shortcomings many alloys were developed based on the NiAl. NiAl–28Cr–6Mo (NiAl–Cr(Mo) for short) eutectic alloy was regarded as one of the most hopeful alloys due to its relative good room-temperature (RT) and high-temperature mechanical properties [3–5]. In order to improve the high-temperature strength of the NiAl–Cr(Mo) eutectic alloy further, Hafnium (Hf) was introduced in the alloy. However, the Ni_2AlHf strengthened phases formed along the eutectic cell boundaries weakened the room-temperature fracture toughness and compressive ductility of the alloy severely [6–8].

For NiAl–Cr(Mo)–Hf eutectic alloy with Ni_2AlHf strengthening precipitates, a feasible way to improve its ductility is to reduce the micro-segregation of Ni_2AlHf phases. Solidification at high cooling rate and high temperature–high pressure treatments are anticipated to attain these purposes. As a popular method to fabricate bulk amorphous [9,10], suction casting can obtain a relatively high cooling rate of about $50 \sim 10^2$ K/s that is much higher than $10^{-1} \sim 10^{-2}$ K/s for the conventional casting. Previous researches [11,12] have reported that the rapid solidification can improve the mechanical properties of the NiAl-based alloy significantly. However, few investigations have been done on the effect of hot isostatic pressing (HIP) treatment on the rapid solidified NiAl–Cr(Mo)–Hf eutectic alloy. Therefore in the present paper the microstructure and mechanical properties of suction-cast NiAl–28Cr–5.7Mo–0.3Hf alloy with and without HIP treatment were investigated.

2. Experimental

Alloy ingots with a composition of NiAl–28Cr–5.7Mo–0.3Hf (at.%, NiAl–Cr(Mo)–Hf for short) were prepared in a vacuum induction furnace and cast into rods of 30 mm in diameter. Then, selected samples of the above alloys were investigated in the as-cast state;

* Corresponding author. Institute of Industry Technology, Guangzhou & Chinese Academy of Sciences, Guangzhou 511458, China. Tel.: +86 20 34685712; fax: +86 20 34685580.
E-mail address: lysheng@imr.ac.cn (L.Y. Sheng).

0966-9795/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.intermet.2009.05.003

the remaining samples were crushed for suction casting. The suction-casting experiments were conducted with a water-cooled copper mold method. Firstly an appropriate amount of alloy was melted again in a quartz crucible in high vacuum with argon atmosphere. Then the remelted alloy was sucked into a copper mold, which has inner cavity with a size of φ 5 mm $\times$ 80 mm and is cooled by high-speed water. Some suction-cast samples were observed and tested at as suction-cast state; other suction-cast samples were HIP treated at 1300 °C/150 MPa for 3 h.

Microstructural characterizations of the conventionally cast, suction-cast and HIP-treated suction-cast alloys were carried out by S-3400 scanning electron microscope (SEM) with energy dispersive spectrometer (EDS). The compositions of constitute phases were detected by EPMA-1610 electronic probe microanalysis (EPMA).

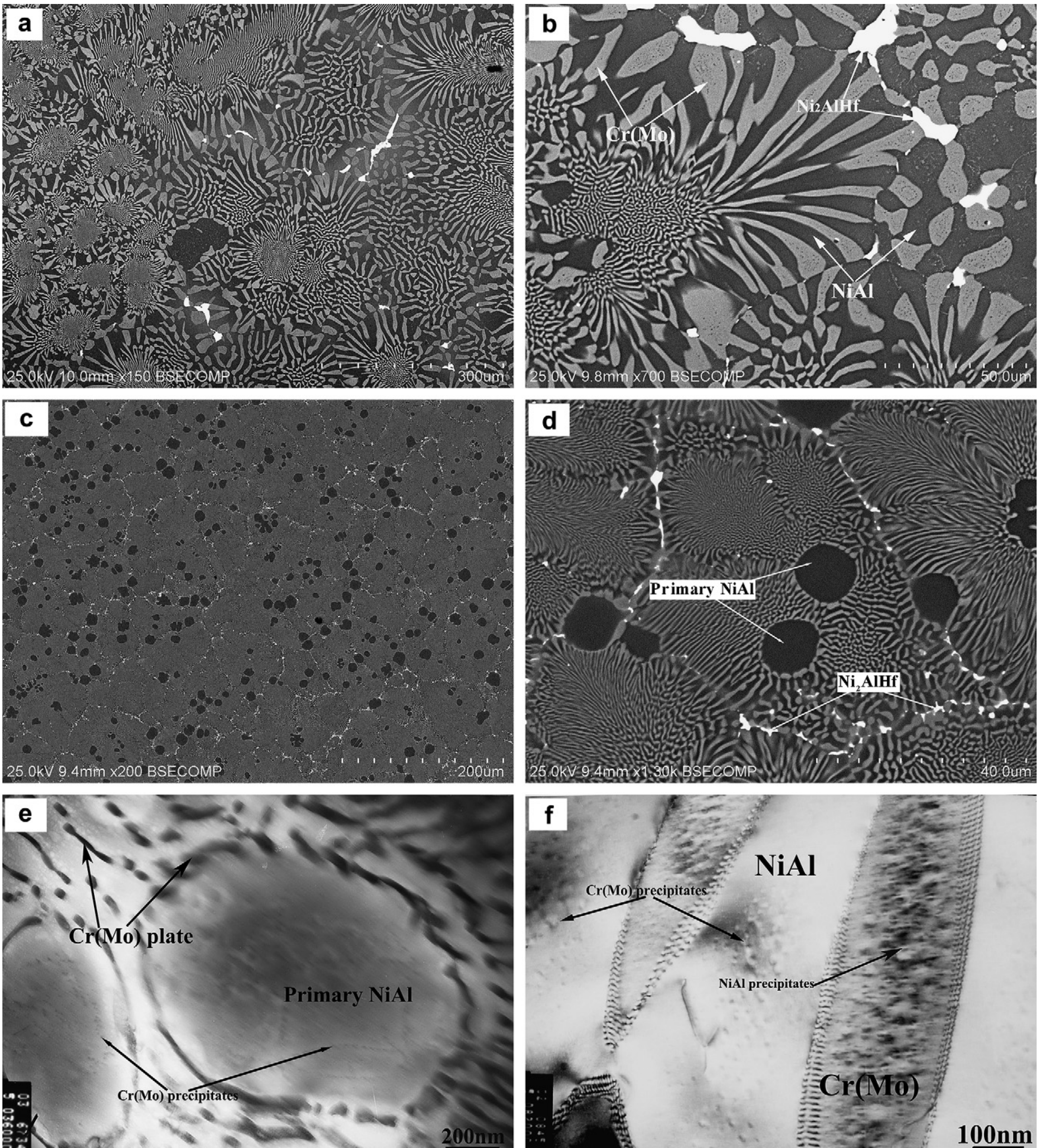

Fig. 1. (a) SEM micrographs of the conventionally cast alloy, (b) coarse eutectic cell and Ni_2AlHf phases, (c) SEM micrographs of the suction-cast alloy, (d) fine primary NiAl phase and Ni_2AlHf precipitates, (e) fine Cr particles precipitating inside primary NiAl phase, (f) Misfit dislocation network at the NiAl/Cr(Mo) interface, fine Cr(Mo) precipitate in NiAl matrix and NiAl precipitate in Cr(Mo) phase.