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Effects of carbon and boron addition on microstructure and mechanical properties of TiAl alloys

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Abstract
The effects of carbon or boron addition on microstructure, mechanical properties, phase composition and distribution of the carbides and borides in Ti-48Al alloys were studied in this paper. Carbon and boron were added into Ti-48Al by various styles, such as boron powers or carbon powers, TiB_2 and TiC powers and B_4C powers. The ingots were prepared by induction skull melting (ISM) with a water-cooled copper crucible. The tensile tests and fracture toughness tests at room temperature were investigated. Meanwhile, the as-cast microstructures were analyzed by the scanning electron microscope (SEM) and the transmission electron microscope (TEM). The grain sizes were estimated by a line intercept technique on at least ten OM micrographs and EBSD. It could be observed that the Ti-48Al alloys containing 0.2at.%B_4C with smaller grains exhibited the excellent tensile strength and elongation among the alloys, 517MPa and 0.471%, respectively. The effects of boron and carbon addition on distribution of borides and carbides were analysed. It could be found that borides and carbides distributing uniformly in microstructure also provided better fracture toughness for Ti-48Al-0.2B_4C alloys.
Key words: TiAl alloy; Borides; Carbides; Aggregation of borides; Mechanical properties

1.Introduction

TiAl alloys have gained interests for the research on aerospace applications resulting from the low density and high specific strength[1,2]. Early researches reported γ-TiAl alloys exhibiting fine properties[3,4]. Nevertheless, the most important prerequisites for advanced applications of TiAl alloys are probably excellent ductility at room temperature. Therefore, more researches concentrated on the ways to improve ductility and elongation of TiAl alloys at room temperature. The boron or carbon addition in lamellas could cause a substantial increase in properties, such as microstructure refinement (grain sizes and lamellar spacing) and high strength[5,6]. When nucleation takes place in borides precipitated at higher temperature from the β phase, the nucleation of α phase forming on surface of borides (within the melting interdendritic regions) or the large number of possible α phase orientations available result in the refinement of microstructure[7]. Tian[8] has studied that the carbon addition in TiAl alloy can improve the properties obviously because of grain refinement and carbides forming such as (001)Ti_3AlC//(001)TiAl, [010] Ti_3AlC// [010]TiAl, needle//[001]TiAl and (0001)Ti_2AlC//(111) TiAl , [1120]Ti_2AlC//[101]TiAl, plate//{111}TiAl.

TiB_2[9,10], C[11], B_4C[12] addition could refine grain or lamellar spacing and pin interface to improve the ductility and strength. However, there are few researches in comparison about the effect of various styles of B and C addition on the microstructure and properties, such as B powers, C powers, TiB_2 powers, TiC powers or B_4C powers. Larsen [13] reported that with