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A novel fabrication technology of in situ TiB_2 /6063Al composites: high energy ball milling and melt in situ reaction

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Abstract: TiB_2/6063Al matrix composites are fabricated from Al-TiO_2-B_2O_3 system by the technology combining high energy ball milling with melt in situ reaction. The microstructure and tensile properties of the composites are investigated by XRD, SEM, EDS, TEM and electronic tensile testing. The results indicate that high energy ball milling technology decreases the in situ reaction temperature and shortens the reaction time for Al-TiO_2-B_2O_3 system in contrast with the conventional melt in situ synthesis. The morphology of in situ TiB_2 particles is exhibited in irregular shape or nearly circular shape, and the average size of the particles is less than 700 nm, thereinto the minimum size is approximately 200 nm. In addition, the morphology and size of the reinforced particles are affected by the time of ball milling and in situ reaction. TEM images indicate that the interface between 6063Al matrix and TiB_2 particles is clear and no interfacial outgrowth is observed. Tensile testing results show that the as-cast TiB_2/ 6063Al composites exhibit a much higher strength, reaching 191 MPa, which is 1.23 times as high as the as-cast 6063Al matrix. Besides, the tensile fracture surface of the composites displays the dimple-fracture character.

Keywords： Aluminum matrix composites; high energy ball milling; Melt in situ reaction; Microstructure; Tensile properties

1. Introduction

Aluminum matrix composites, especially particles reinforced aluminum matrix composites, with low density, high specific strength and stiffness, good thermal stability and wear resistance, play an important role in aerospace, automotive, military and other fields [1-4]. Common reinforced particles in the composites include borides, carbides, and oxides [5-8]. Among them, Borides as ultra high-temperature ceramics are generally desirable materials to be used in a variety of industries owing to their improved properties [2, 9]. In particular, TiB_2 is the most stable compound between Ti and B elements, which possesses many desirable properties, such as high melting point, high hardness and high elastic modulus as well as good chemical stability and corrosion resistance. Furthermore, TiB_2 not only has favorable thermal conductivity, but also exhibits good electrical conductivity, which is an excellent reinforcement. In view of the above advantages, TiB_2 reinforced aluminum matrix composites can be widely used in high temperature resistant, wear-resistant, corrosion resistant parts and other special requirements, thus TiB_2 is attractive to extensive attentions and further studies. H.B. Michael Rajan et al. [10] fabricated aluminum alloy AA7075 reinforced TiB_2 particulate composites by the in situ reaction of K_2TiF_6 and KBF_4 to molten aluminum and reported that TiB_2 particles were effective to enhance the wear resistance of the aluminum matrix composites.

In recent years, many researchers at home and abroad had studied for the fabrication technology of high energy ball milling and melt in situ reaction [11, 12]. A large number of experimental studies indicated that both high energy ball milling and melt in situ reaction could fabricate particles reinforced aluminum matrix composites with excellent performances. But these two methods have their own limitations. For high energy ball milling, the size of nano-particles is not uniform. Especially, the powders are serious aggregate at the final stage of ball milling.

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