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Microstructure and mechanical properties of *in situ* TiC and Nd_2O_3 particles reinforced Ti–4.5 wt.%Si alloy composites

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ABSTRACT

($TiC + Nd_2O_3$)/Ti–4.5 wt.%Si composites were *in situ* synthesized by a non-consumable arc-melting technology. The phases in the composites were identified by X-ray diffraction. Microstructures of the composites were observed by optical microscope and scanning electron microscope. The composite contains four phases: TiC, Nd_2O_3, Ti_5Si_3 and Ti. The TiC and Nd_2O_3 particles with dendritic and near-equiaxed shapes are well distributed in Ti–4.5 wt.%Si alloy matrix, and the fine Nd_2O_3 particles exist in the network $Ti + Ti_5Si_3$ eutectic cells and Ti matrix of the composites. The hardness and compressive strength of the composites are markedly higher than that of Ti–4.5 wt.%Si alloy. When the TiC content is fixed as 10 wt.% in the composites, the hardness is enhanced as the Nd_2O_3 content increases from 8 wt.% to 13 wt.%, but the compressive strength peaks at the Nd_2O_3 content of 8 wt.%.

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1. Introduction

Titanium and its alloys have been widely used as the ideal matrix for developing reinforced metal matrix composites because of their high specific modulus, high specific strength, high fracture toughness and heat resistance [1–3]. To the Ti–Si alloys, the intermetallic compound Ti_5Si_3 phase, as the reinforcement in the titanium matrix, can significantly improve some properties of the titanium matrix because of its high melting point (2130 °C), low density (4.32 g/cm^3), good oxidation resistance and creep resistance [3–7].

Particle reinforced titanium matrix composites (PRTMCs) have considerable potential for structural applications in fields of aerospace and automobile industries for the improvement of various mechanical properties (especially stiffness, strength and wear resistance), over conventional titanium alloys [8,9]. In recent years, *in situ* compositing technology has been developed to prepare PRTMCs, such as self-propagation high-temperature synthesis [10], rapid solidification [11,12] and casting [1,13]. This technology offers an attractive set of advantages: low fabrication cost, stable interface, fine reinforcement. The numerous works have shown that many particle-reinforcements can been directly fabricated in the titanium matrix composites by the *in situ* technology. Especially, TiC particle is a preferential candidate as the reinforcement due to its high hardness, high modulus and high flexural strength [14–16]. Moreover, the rare earth oxide (RE_2O_3) was proved to be valuable to grain refinement, fatigue resistance and thermal stability [17,18]. Thus, for developing new structural materials to extend the application of *in situ* PRTMCs, it is promising for the introduction of *in situ* TiC and RE_2O_3 particles in the titanium alloys to obtain excellent mechanical property.

In the present work, ($TiC + Nd_2O_3$)/Ti–4.5 wt.%Si composites were *in situ* synthesized by the direct melting reaction between Ti, Si, Nd, C and SiO_2. The phase components and microstructures of the composites were systematically investigated, and the synergistic effect of TiC and Nd_2O_3 reinforcements on the mechanical properties of the composites was also studied.

2. Experimental procedure

($TiC + Nd_2O_3$)/Ti–4.5 wt.%Si composites utilizing the reaction between Ti, Si, Nd, C and SiO_2 were *in situ* synthesized through melting in a non-consumable vacuum arc remelting furnace. The raw materials were sponge Ti (>99.9% purity), Si (>99.9% purity), Nd (>99.9% purity), C powder (>99.9% purity) and SiO_2 powder (>99.9% purity). To investigate the morphologies and enhanced effect of Nd_2O_3 reinforcement, three different contents of neodymium dioxide were designed in the composites. Moreover, Ti–4.5 wt.%Si alloy was also prepared. In order to ensure the chemical homogeneity of the composites, each ingot was turned over and remelted for five times. The weight percentage of reactants and theoretical weight percentage of TiC and Nd_2O_3 products are listed in Table 1.

Phase identification of the samples was carried out via X-ray diffraction (XRD) using Rigaku D/max-2200 diffractometer with Cu Kα radiation. The metallographical samples were prepared using conventional grinding and mechanical polishing techniques.

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