



Short Communication

Effect of in situ synthesized TiB whisker on microstructure and mechanical properties of carbon–carbon composite and TiB_w/Ti–6Al–4V composite jointTiesong Lin^a, Minxuan Yang^a, Peng He^{a,*}, Chao Huang^b, Feng Pan^a, Yudong Huang^c^aState Key Laboratory of Advanced Welding Production Technology, Harbin Institute of Technology, Harbin 150001, China^bAerospace Research Institute of Materials & Processing Technology, China^cSchool of Chemical Engineering and Technology, Harbin Institute of Technology, Harbin 150001, China

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ABSTRACT

Carbon–carbon composite (C–C composite) and TiB whiskers reinforced Ti–6Al–4V composite (TiB_w/Ti–6Al–4V composite) were brazed by Cu–Ni + TiB₂ composite filler. TiB₂ powders have reacted with Ti which diffused from TiB_w/Ti–6Al–4V composite, leading to formation of TiB whiskers in the brazing layer. The effects of TiB₂ addition, brazing temperature, and holding time on microstructure and shear strength of the brazed joints were investigated. The results indicate that in situ synthesized TiB whiskers uniformly distributed in the joints, which not only provided reinforcing effects, but also lowered residual thermal stress of the joints. As for each brazing temperature or holding time, the joint shear strength brazed with Cu–Ni alloy was lower than that of the joints brazed with Cu–Ni + TiB₂ alloy powder. The maximum shear strengths of the joints brazed with Cu–Ni + TiB₂ alloy powder was 18.5 MPa with the brazing temperature of 1223 K for 10 min, which was 56% higher than that of the joints brazed with Cu–Ni alloy powder.

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1. Introduction

C–C composites have successfully demonstrated their potential in aerospace and automotive applications because of their low density, excellent oxidation resistance, and high-temperature strength [1–3]. In most cases, the applications of C–C composites require joining of C–C composites to metals. As a metal-based material, TiB_w/Ti–6Al–4V composite is regarded as a high mechanical strength and high-temperature resistance material compared with Ti–6Al–4V alloy which is usually used in aerospace area. Hence, the reliable joining of C–C composites and TiB_w/Ti–6Al–4V composite will be helpful for extending their applications.

Brazing has been developed as a main method for joining composites to metals [4–6]. However, the mismatch of thermal expansion coefficient (CTE) between metals or brazing alloy and composites or ceramics will cause high thermal residual stress in joining interface and result in degradation of brazed joints [7]. Especially, CTE of C–C composite is $0\sim 2 \times 10^{-6}/^{\circ}\text{C}$, which is far less than $8.6 \times 10^{-6}/^{\circ}\text{C}$ of Ti–6Al–4V alloy. Hence, the degradation of C–C composite and TiB_w/Ti–6Al–4V composite joint caused by thermal residual stress will be more serious. Low CTE reinforcements have been added into brazing alloy to lower its CTE. The brazed joints of Al₂O₃/Al₂O₃ [8], C–SiC/Ti alloy [9,10] and Si₃N₄/Si₃N₄ [11] have been brazed with modified Ag–Cu–Ti alloys which

were added with low CTE particles, such as SiC, carbon fiber, TiC, W, and so on. However, CTE modification method has many intrinsic limitations. The reinforcements are difficult to be distributed evenly in brazing alloy and reinforcements always have bad wetting ability with intermetallics [12].

Liu et al. [13] have improved the mechanical strength of Si₃N₄ brazed joints with in situ synthesized reinforcement of Ni–Ti intermetallics during brazing process. It was reported that in situ synthesized reinforcements originated from brazing process have greater reinforcing effects due to their fine size, uniform distribution, favorable cohesion with matrix, and good wettability. In this paper, Cu–Ni alloy powder reinforced by in situ synthesized TiB whiskers during brazing was used to braze C–C composite to TiB_w/Ti–6Al–4V composite. The effects of TiB whiskers on the braze joints microstructure and the joint shear strengths in room temperature were investigated.

2. Experimental procedures

TiB_w/Ti–6Al–4V composite (titanium alloy reinforced by 5 vol.% TiB whiskers) was fabricated by reaction hot pressing, and C–C composite ($\rho = 1.78 \text{ g/cm}^3$) was made by chemical vapor infiltration process with polyacrylonitrile billet. C–C composite was cut into the samples with size of $8.0 \times 8.0 \times 8.0 \text{ mm}^3$ by wire electro-discharge machining. TiB_w/Ti–6Al–4V composite was cut into $8.0 \times 8.0 \times 3.0 \text{ mm}^3$ slices for metallographic investigation and $24.0 \times 8.0 \times 3.0 \text{ mm}^3$ for shear test, respectively. The brazing

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