Materials and Design 32 (2011) 388–394

Contents lists available at ScienceDirect

Materials and Design

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

Short Communication

Effect of vacuum heat treatment on microstructure and microhardness of cold-sprayed TiN particle-reinforced Al alloy-based composites

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ARTICLE INFO

Article history:
Received 26 February 2010
Accepted 2 June 2010
Available online 8 June 2010

ABSTRACT

Cold spraying (CS) demonstrates great potentials in fabrication of metal matrix composites. The effect of post-spray heat treatment at 250 °C, 350 °C and 450 °C for 2 h on the microstructure and properties of CS Al5356/TiN composites was examined in this study. The results show that the heat treatment has little effect on the distribution of TiN particles in the matrix of all the composites. The pure Al5356 deposit presents large pores between the deposited particles after heat treatment, which is a common phenomenon for CS metallic coatings having an apparent increasing porosity during annealing. The adhesion between the deposit and substrate could be enhanced through atom diffusion, especially at elevated temperatures. However, the microhardness of all the deposits is significantly reduced after heat treatment because of the release of work-hardening effect within the as-sprayed metallic particles.

1. Introduction

Al and its alloys find applications in automobile, defense and aerospace sectors in terms of their specific weight and thermal conductivity. However, they have poor tribological performance. The fabrication of Al and its alloys-based metal matrix composites (MMCs) is of great significance in applications owing to their excellent combination of higher specific strength and improved wear resistance over their base alloys. The particle-reinforced MMCs are among the most widely used composite materials, which can be produced through a number of routes including melt processing and powder metallurgy, such as casting, sintering, hot pressing [1] and thermal spraying (TS) [2].

In recent years, the emerging cold spraying (CS) technique has been increasingly investigated owing to its high deposition efficiency and volume production of coatings or parts, involving pure metals, alloys and composites [3–5]. It is widely accepted that in this process the deposition of particles takes place through their intensive plastic deformation upon impact in a solid state at a temperature well below the melting point of spray material. Consequently, the deleterious effects such as oxidation, decomposition and grain growth inherent to conventional TS techniques can be minimized or eliminated [3]. An important advancement of CS is the fabrication of advanced MMCs, especially light metals. The previous studies showed that MMCs could be produced via a simple powder blend with the low pressure CS system [4]. Therefore, the low cost fabrication of MMCs by CS is very attracting. However, there are some fundamental aspects to be considered with regard to CS MMCs. For instances, the deposited MMCs had much less volume fraction of hard particles than that in the blend. The interfacial bonding between the reinforcing particles and the matrix is also an important consideration besides the volume fraction and distribution of reinforcement. In addition, the resultant MMCs present probably low toughness due to the increasing hardness and weak interfacial bonding.

A literature survey reveals that besides the CS deposition of composites through the simple powder blends, such as Al–Al_2O_3 [6], Al–SiC [7], Al–TiN [8,9] and Al12Si–SiC [10], some useful methods were introduced to improve the composite performance, which pay attention to the preparation of feedstocks. Li et al. [11] deposited the Al5356/TiN (50 wt.%) composite with the ball-milled blend (BM composite). The BM composite presented a dense structure with more fine TiN particles uniformly dispersed in the matrix compared to the composite obtained via the simple Al5356/TiN (50 wt.%) blend (MM composite) [8]. The volume fraction of TiN in the BM composite was greatly increased, and thus an improved wear resistance was obtained compared to the MM composite [8]. Kim et al. [12] prepared the feedstock through the Ti/B/Cu elemental powders, which were milled for 2 min and then ignited to initiate self-propagating reaction to form titanium diboride (TiB_2). The product of reaction was then milled to decrease the size of TiB_2 particles. The deposited TiB_2–Cu nanocomposite presented a dense structure and much high hardness [12]. Phani

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doi:10.1016/j.matdes.2010.06.002