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Materials Letters 61 (2007) 635–638
materials letters
www.elsevier.com/locate/matlet

Microstructures and wear properties of in situ formed composite coatings produced by laser alloying technique

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Received 18 December 2004; accepted 14 May 2006
Available online 8 June 2006

Abstract

Laser-surface alloying of titanium alloy Ti–6Al–4V with C and Si mixed powders has been carried out. The composite coatings, thickness of about 0.7 mm, mainly consisting of titanium carbides and silicides, have a hardness of about 1500 $HV_{0.1}$, and the wear resistance is 4 times more than that of the as-received.

Keywords: Laser alloying; Titanium carbides and silicides; Wear resistance

1. Introduction

In view of the excellent combination of high temperature strength and lightweight properties, titanium-based alloys are more attractive for the manufacture of structural components in aerospace, chemical, petrochemical and marine industries. However, they are currently restricted to non-tribological applications due to their poor friction and wear resistance and a high tendency to galling. Surface modification is one of the most efficient means to improve the tribological properties of titanium alloys and of all the surface modification techniques, laser alloying is finding increasing use in surface modification of many kinds of metals [1–3].

Laser nitriding is an effective method to improve the wear and corrosion resistance of titanium and its alloys. But the cracks in the alloyed layers produced by laser nitriding in a pure nitrogen gas environment are a bane to the strength and toughness of the alloy [4,5]. Titanium carbides and silicides such as TiC and Ti_5Si_3 are confirmed to be good reinforcements for titanium alloys because of their excellent capabilities including high hardness and wear resistance in many tribological systems, thermal stability at high temperature, high elastic modulus and the similar density to pure titanium [6–8] and surface modification of titanium alloys with titanium carbides or silicides is considered to be effective method to improve the wear resistance of titanium alloys [7–9]. So, in the present study, the laser alloying with graphite and silicon mixed powders was performed to modify the surface properties of titanium alloy Ti–6Al–4V. The microstructure, the phase composition and the wear resistance of the surface alloyed layers were investigated.

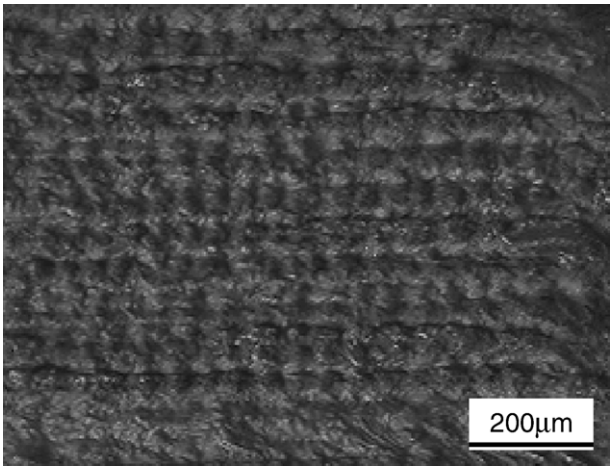

Fig. 1. The surface morphology of the laser alloyed layer of sample 1.

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doi:10.1016/j.matlet.2006.05.035

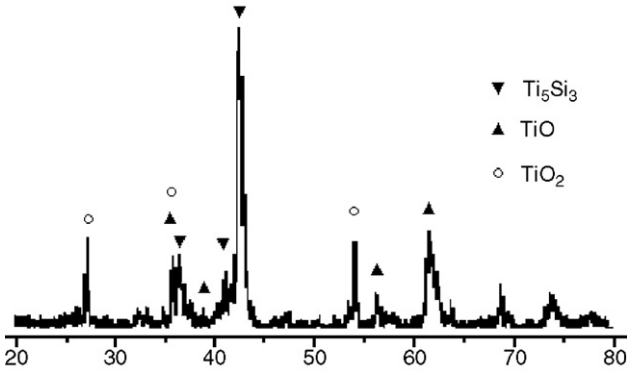

Fig. 2. XRD spectrum of the sample 1.

2. Experimental procedures

The samples of titanium alloy Ti–6Al–4V, 10 × 10 × 30 in size, were abraded with SiC grit paper prior to the coating operation. Graphite and silicon mixed powders, an average particle size of 10 μm, with different weight ratios (2:1, 1:1 and 1:2), blended with diluted polyvinyl alcohol solution were coated on the surface of the samples in a thickness of approximately 0.5 mm. A 1500 W continuous wave CO_2 laser, output power of 1200 W, beam size of 2 mm, scanning speed of 3.5 mm/s was employed to melt the preplaced coatings together with the surface layer of the samples. To protect the melt pool from oxidation during processing, argon gas shield at a pressure of 0.35 MPa was fed through a nozzle

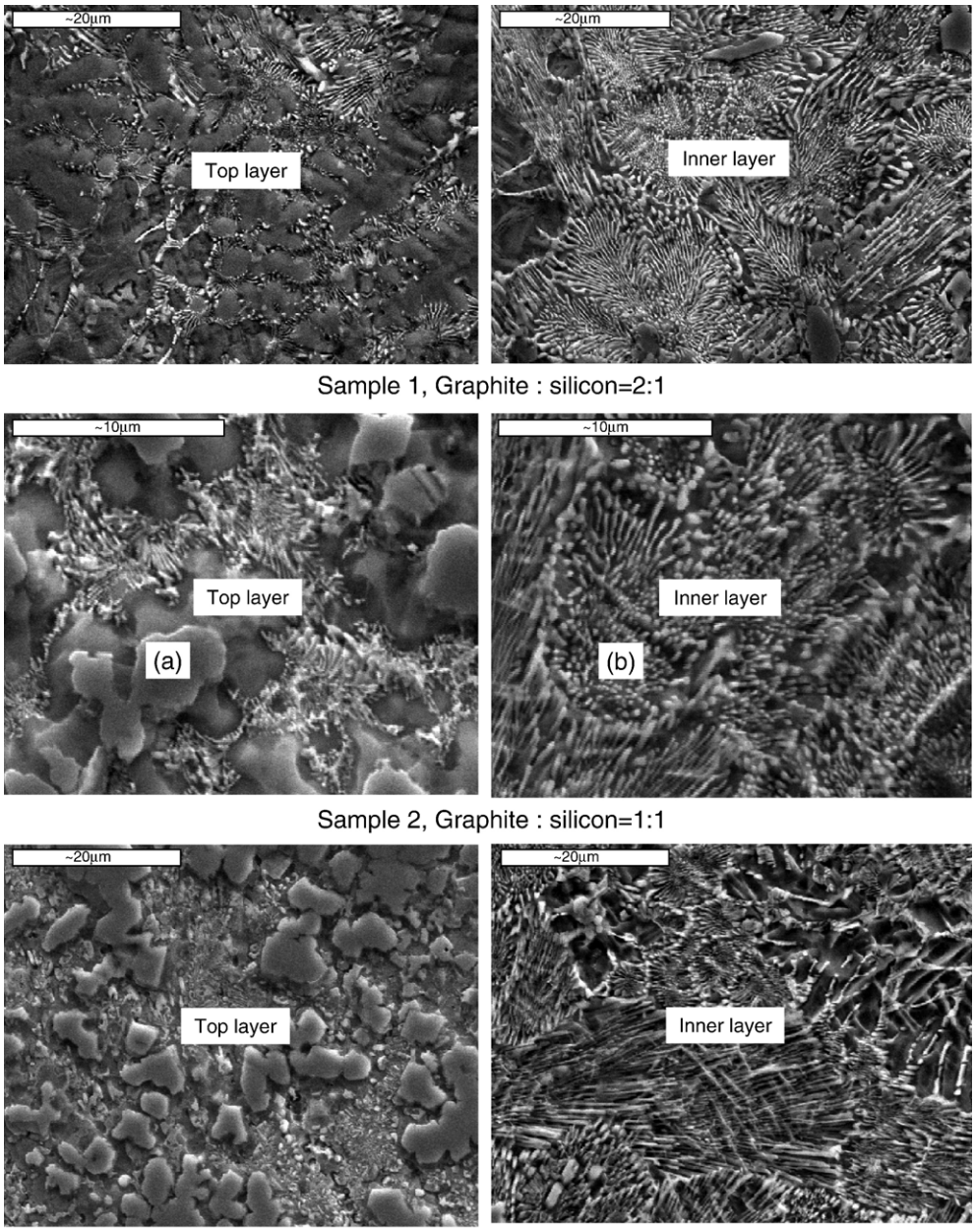

Fig. 3. EMPA micrographs of the samples.