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Wear improvement of sol–gel silica coatings on A380/SiCp aluminium composite substrate by diode laser sintering

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ABSTRACT

In this investigation, a high power diode laser (HPDL) was used to induce the microstructural refinement on the surface of a SiC particulate (SiCp) reinforced Al-based metal matrix composite (A380/SiC/20p) and, at the same time, to the sintering of a sol–gel ceramic layer deposited on the surface of the mentioned substrate. The purely inorganic silica ceramic coating was synthesised through the organic sol–gel route, using tetraethoxysilane (TEOS) as alkoxide precursor and the dip-coating as the deposition technique on the surface of the A380/SiC/20p composite. Optimisation of the laser parameters led to homogeneous and free of cracking coatings and also to the refinement of the surface microstructure of the substrate by means of the dissolution of the intermetallic precipitates, the decrease in the aluminium dendrites size and a better distribution of the silicon carbide particles. Unlubricated pin-on-disc wear tests confirmed the increase (89% in terms of specific wear rate drop) in the wear resistance of the coated substrates treated by the HPDL.

1. Introduction

The aluminium matrix composites reinforced with silicon carbide particles (SiCp) have high wear resistance, stiffness and thermal stability. These properties make them suitable for a number of applications in automotive, aerospace and engineering components [1]. Most of these composites present low corrosion properties, because of the presence of discontinuities in the natural alumina protective coating at the interfaces between matrix and reinforcement, as well as because of the existence of coarse intermetallic phases at their surface [2].

In order to improve the corrosion behaviour of different composites and alloys, without reducing their tribological properties, ceramic coatings are usually applied [3,4]. These coatings can be obtained by Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD) process; however these technologies demand cost intensive equipment. Sol–gel processing is a cost-effective alternative to generate ceramic coatings with the required thickness for many purposes, including wear and corrosion protection.

Authors have studied in previous works the protection of aluminium matrix composites by means of silica coatings through sol–gel methods [5] to increase their corrosion [3] and wear resistance [6]. Moreover, alternative method was studied in order to recover the mechanical properties of the coated composite based on quenching of the coated substrate after the heat treatment of densification [7]. In these previous works densification of the final ceramic coatings were achieved by heat treatments in oven.

Nowadays, different densification processes for the fabrication of ceramic sol–gel coatings on metallic substrates are under investigation, in order to enhance the coating consolidation and to develop time-saving techniques, such as densification by ultraviolet irradiation and water vapour [8], high power CO_2 and Nd:YAG lasers [9,10], or excimer laser annealing [11]. Even, a novel laser technique has been used for the in situ deposition of the ceramic sol–gel layer by immersing the substrate in the sol solution, an irradiating its surface with a laser while it was still inside the sol [9]. In previous investigation [7] authors have demonstrated the effectiveness in corrosion protection of aluminium matrix composites by means of silica sol–gel coatings sintered using a high power diode laser (HPDL).

Pardo et al. have successfully refined the surface microstructure of different aluminium matrix composites, reinforced with different volumetric proportion of SiC particles, via HPDL [12,13]. The laser surface melting (LSM) reached allows, after the optimisation of the laser parameters, not only the dissolution of the cathodic second phase particles (intermetallic precipitates) and therefore increases the corrosion behaviour of the composite, but also a refinement of the dendrite size and a better distribution of the SiC particles (SiCp) with the subsequent enhancement of the surface hardness.

The aims of the present work are to induce the microstructural refinement on the surface of a SiC particulate reinforced Al-based metal matrix composite (A380/SiC/20p) and the sintering of a silica

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