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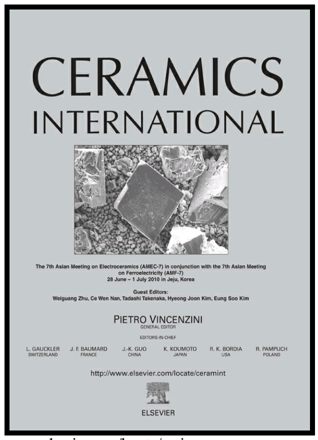

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Prepare SiTiOC Ceramic Coatings by Laser Pyrolysis of Titanium Organosilicon Compound

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Abstract

A SiTiOC ceramic coating with outstanding tribological performance was prepared by laser scanning the organosilicon coating with different laser power. The composition and structure of the obtained SiTiOC ceramic coatings were analyzed by scanning electron microscopy (SEM), infrared spectroscopy (FTIR), Raman spectra, X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and transmission electron microscope (TEM). The tribological performance of the coatings was studied using a multi-functional reciprocating friction and wear tester. The results showed that the chemical structure (chemical bonding) of the coatings prepared at 0 W, 350 W, and 500 W laser powers included Si-O-Si, Si-C, and TiO_2, while that prepared at 800 W was mainly composed of amorphous SiO_2, indicating that the coating had higher ceramization. The SiTiOC ceramic coatings prepared by the present process effectively reduced the friction coefficient and wear volume of the steel substrate, which indicated that they had good anti-friction and wear resistance properties.

Key words

laser pyrolysis; titanium organosilicon compound; ceramic coating

1 Introduction

Polymer precursor derived ceramic (PDC) synthesis is an effective way to prepare ceramic coatings on the surface of metal materials in-situ, and can give metallic parts both the high strength and toughness performance of the base metal and the high temperature, corrosion, and wear resistance of a ceramic [1]. Currently, metal-based ceramic coatings have been widely used in aerospace, national defense, chemical, mechanical, power, electronics, and other industrial fields[2-3].

The ceramic synthesized via PDC method has excellent wear and corrosion resistance and its particles are small, uniformly distributed, and have good adhesion to the metal substrate, it still has a large porosity and is prone to cracking due to shrinkage during pyrolysis [4]. To solve these problems, Ti, Al, Ni, Mo, Cr and other active fillers [5-9] have been added into the pyrolysis system to form new ceramic phases during the pyrolysis of the precursor. These new phases appear after the active fillers react with the by-product or atmosphere during pyrolysis [10] and are expected to reduce the porosity and suppress the cracking of the ceramic coatings by the volume expansion [11] and endow the product special performance. For example, Proust et al.[12] pyrolyzed Allylhydridopolycarbosilane(AHPCS) with the nano titanium powder as active filler at 1000℃ to prepare the bulk Si-C-Ti composite ceramics and reported the density of ceramic increased significantly with the increasing ratio of AHPCS and Ti powder, the max hardness of which is 209HV. Li et al.[13-14] reported that the SiAlC ceramic, prepared by pyrolysis of polyalumincarbosilane (PACS), was observed to have better heat stability and corrosion resistance with the addition of element Al. However, the micro- or nanopowder active fillers added to the organic polymer precursor can agglomerate and become unevenly dispersed, which is not conducive to the preparation of high performance ceramic coatings. The use of metallic element-containing organic polymers as precursors to prepare ceramic (SiMOC) coatings can effectively avoid the uneven dispersion of filler particles, reduce the coating porosity, and suppress cracking. However, the PDC method still has some problems, such as a complicated preparation process long preparation period. To improve the PDC process further, the typical high-temperature heating source can be replaced with a laser because its high energy density and easy process control.

In this study, γ-glycidoxypropyltrimethoxysilane was chemically reacted with tetrabutyl titanate to prepare a titanium organosilicon precursor. Titanium organosilicon coatings were prepared on metallic surfaces and then scanned with a continuous laser to prepare SiTiOC ceramic coatings. The composition and structure of the SiTiOC ceramic coatings were analyzed, and their tribological performance was investigated.

2 Experiment and methods

To prepare the precursor, 100 g of γ-glycidoxypropyltrimethoxysilane ($C_9H_{20}O_5Si$, industrial grade) was poured into a 500 mL beaker and subjected to ultrasonication for 5 min at room temperature. Next, 100 g of tetrabutyl titanate ($C_{16}H_{36}O_4Ti$, analytically pure) was added to the beaker slowly and the mixture was ultrasonicated for 10 min to obtain a titanium organosilicon compound.

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