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TRIBOLOGICAL BEHAVIOUR OF CERAMIC COATING

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ABSTRACT

Titania or titanium di-Oxide (TiO_2) is a multi functional ceramic material having many potential applications, such as medical technology, photo catalysis and wear protection. In this study, Titania and TiO_2+10% SiC coating was deposited on titanium substrate by High Velocity Oxy-Fuel (HVOF) spraying. The Microhardness and porosity of the coatings was measured using Vickers microhardness tester on coating cross section and bond strength was measured as per ASTM C633. The XRD analysis identifies the rutile as major phase and presence of secondary phases in TiO_2-SiC coating. The sliding wear behavior of substrate, coatings was evaluated using Pin-on-disk apparatus as per ASTM G99 standard. Worn surface morphologies were analysed by SEM and found that the major wear mechanisms are plastic deformation, brittle fracture and micro cutting.

Keywords: *Titania (TiO_2), High Velocity Oxy-Fuel (HVOF) Spraying and Sliding wear*

1. Introduction

Titanium dioxide (TiO_2) or Titania is a very important industrial material attracts much research attention owning to their promising application to photocatalytical, electrical, optical and tribological coatings. Titania has moderate wear resistance mainly due to lower mechanical resistance to deformation, fracture toughness and hardness when compared with other ceramics [1-2]. However, the addition of titania with second phase ultrafine particles selected from the group consist of zirconia, tantalum oxide, boron carbide, silicon carbide(SiC), titanium carbide can improve the wear resistance. Among these SiC offers excellent wear resistance due to its mechanical and chemical stability. In this investigation an attempt has been made to develop Titania (TiO_2) with 10%SiC by High Velocity Oxy-Fuel (HVOF) spray process on titanium substrate and wear behavior of thus developed coatings has been analysed in detail.

2. Experimental

2.1 Thermal spraying

The fused and crushed TiO2 and SiC powders with size ranging between 10-30µm was employed in this study. The coating was deposited by HVOF spraying on Titanium substrate. The substrate was grit blasted by corundum grits of size 320- 500µm and subsequently cleaned using acetone in an ultrasonic bath and dried. The spraying parameters employed during HVOF deposition were: oxygen flow rate -700 lpm, fuel flow rate- 262 lpm, powder feed rate- 33 gpm, spray distance -220 mm and air flow rate -700 lpm.

2.2 Coating characterization

The cross sectional morphology was analysed using optical microscope. The porosity of the coatings was analysed as per ASTM B276 standard on the polished cross-section of the coating, using optical microscope equipped with image analysing system. The microhardness measurement was made using a Vickers Microhardness tester at a load of 300 g and a dwell time of 15 s. A phase composition of as sprayed coating was characterized by X-ray diffraction (XRD) analysis. The tensile bond strength of the coatings was tested as per ASTM-C633. A commercially available heat-curable epoxy was used as an adhesive to test the coated specimens.

2.3 Wear test

Sliding wear test was carried out using Pin-on-disc configuration under dry sliding conditions as per ASTM G99-04. The Ø40 mm uncoated titanium and coated specimens are pressed on rotating wear disc acted as counter surface against WC pin with normal load 30 N. The total sliding distance and sliding speed was 500 m, 300 rpm respectively.

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3. Results and Discussion

Fig 1 shows the SEM morphology of TiO_2 feed stock, which is irregular having some ultrafine particles. Fig. 2 shows the SEM morphology of Titania with 10 % silicon carbide (T10) blended feedstock. Fig 3 shows the cross section of the coatings, which present the partially or unmelted particles embedded in the coating matrix. The melting point of the titania (1850 °C) is lower than SiC, therefore during spraying SiC particles were agglomerated with melted titania particles and deposited over the titanium substrate.

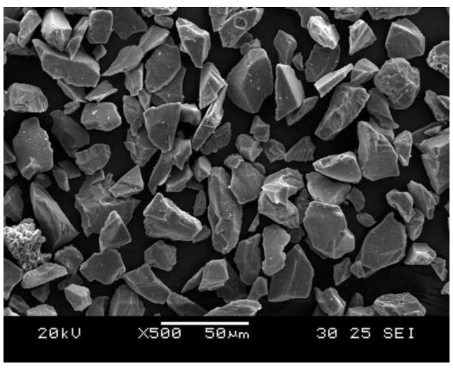


Fig.1 SEM Morphology of TiO_2 Feedstock

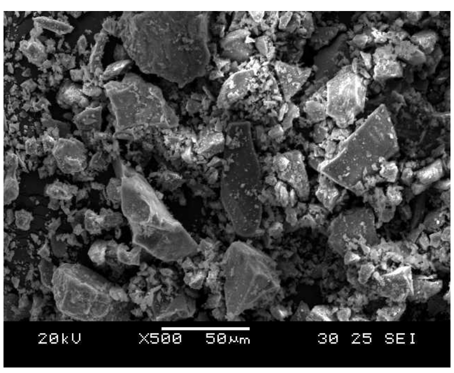


Fig.2 SEM Morphology of T10 Feedstock

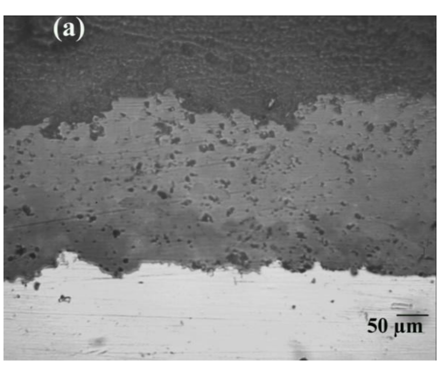


Fig.3 (a) Coating cross section TiO_2

The porosity, microhardness and bond strength of the coating are shown in Table 1. The coating has low porosity level (<2%), high hardness and bond strength. It is thought that, the high impact velocity of the sprayed particles is one of the main factors producing low porosity level, inter-splat cohesion and substrate adhesion [3]. The crystalline phases of SiC are evident from the XRD pattern shown in fig-3. XRD patter confirms presence of TiC and SiO2 second phases exist in the XRD pattern [4].

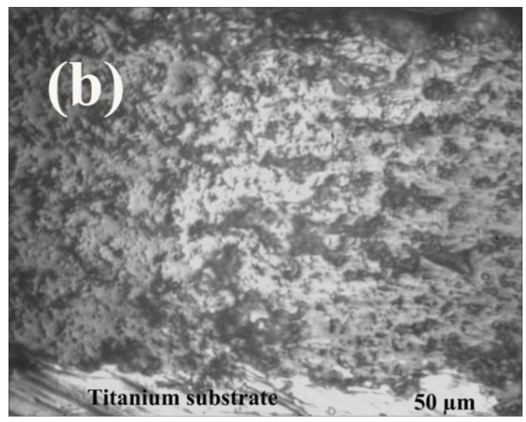


Fig.3 (b) Coating cross section T10

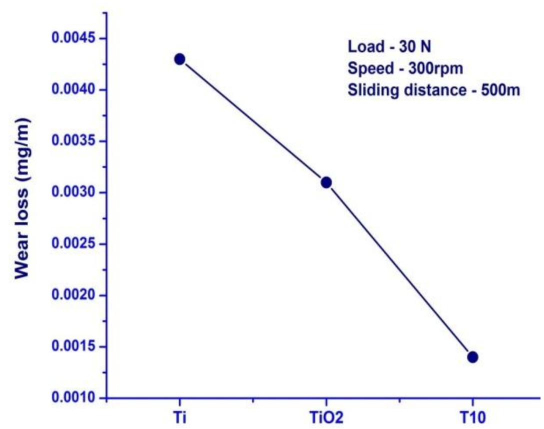


Fig.4 Wear loss

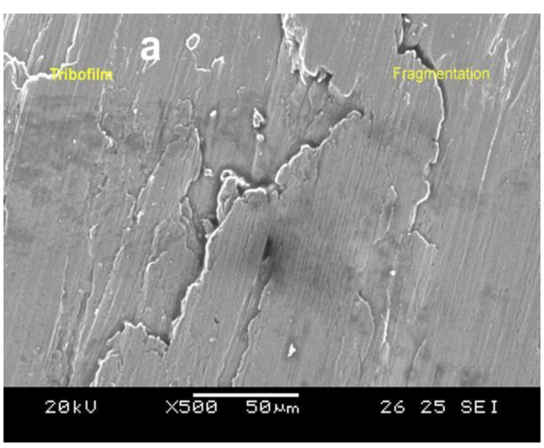
Table 1: Properties of Coatings

Coating	Micro-hardness (HV0.3kg)	Porosity (%)	Tensile Bond strength
T10	958	1.12±0.2	29±3
TiO_2	858	1.86±0.3	19±2

3.1 Tribological performance

Fig 4 shows the sliding wear loss of titanium and coatings. The wear resistance of TiO_2 has improved by incorporation of SiC with Titania coating matrix. The higher wear resistance of 10% SiC coating is due to higher hardness and bond strength of the coating. The observed difference of wear rates of TiO_2 with TiO_2 +10% SiC is the presence of hard phases such as SiC and TiC in the coating which act as load bearing component inhibit plastic deformation and wear. The wear surfaces were analysed by SEM, inorder to understand the wear mechanism of titanium substrate and coating. Fig 5(a) shows the worn surface morphology of titanium surface, the mechanism of wear in titanium is oxidative wear and adhesive wear, the uncoated Titanium shows very high wear rate which may be associated with the preferential transfer of titanium to WC counterface, this was typical adhesive wear [5]. Titanium is chemically active and have a high ductility which gives rise to the strong tendency to adhesion which is well suited with this study[6].

Fig 5(b) shows the SEM morphology of worn surface of T10 coating, it appears to be smooth without many grooves. The wear track shows less wear mode, where plastic deformation and surface polishing are the preferred wear mechanism. It could also be seen that the well adhered tribofilm on the worn surface which is formed by strongly deformed wear debris generated during continuous sliding. These fine particles disperse between the ceramic coating and counterface and act as a bearing agent which can not only bear the applied load but also prevents direct contact results in a decrease in wear rate [7].



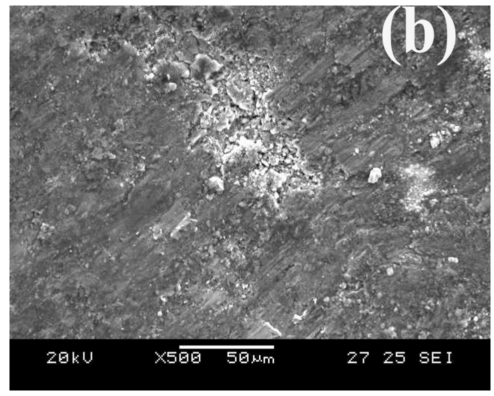


Fig.5 SEM morphology of worn surface (a) titanium (b) T10 coating

4. Conclusions

Titania and SiC reinforced Titania coating was deposited by HVOF spraying on Ti substrate. The addition of SiC in TiO_2 coating matrix enhances mechanical properties and wear resistance of coating. On titanium substrate, adhesive wear is predominant mechanism under sliding wear conditions, where as coatings, plastic deformation and brittle fracture are dominant.

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