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Microarticle

Deposition and characterization of alumina–titania coating by multi-chamber gas-dynamic sprayer

M. Kovaleva [a,*], M. Prozorova [a], M. Arseenko [a], Yu. Tyurin [b], O. Kolisnichenko [b], N. Vasilik [c], V. Sirota [a], I. Pavlenko [a]

[a] Belgorod State National Research University, Pobeda 85, Belgorod 308015, Russia
[b] E.O. Paton Electric Welding Institute, NASU, Bozhenko 11, Kyiv 03650, Ukraine
[c] N.N. Semenov Institute of Chemical Physics, RAS, Kosygina 4, Moscow 117977, Russia

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ABSTRACT

In this paper, alumina–titania coatings have been formed on aluminium substrate by multi-chamber detonation sprayer. The coatings were investigated using SEM, EDS, XRD and Vickers microhardness tester. The results show that the alumina–titania coatings consist of both fully melted regions and partially melted regions, and the fully melted region has a lamellar-like structure. The multi-chamber detonation sprayer produced the dense layers of coating with a high hardness.

1. Introduction

Composites of alumina and titania are known for their high toughness, low thermal expansion, and low thermal conductivity. These properties make alumina–titania composites desirable materials of construction and coatings for high performance applications where thermal barriers are required [1]. Alumina–titania coatings are excellent candidates for providing protection against abrasive wear, and are resistant to high temperature erosion with cryogenic compatibility. It has high thermal shock resistance [2]. When titania is added to Al_2O_3, wear resistance increases, adhesion strength increases and the toughness of the coating improves without changing the hardness [3]. This improves coating performance.

Process of alumina–titania coating formation is usually performed by means of APS, PVD, CVD, HVOF, detonation spraying and other methods [4–7]. Most of the synthetic methods require multistep process, high temperature and also the material preparation is comparatively complex.

In this work, alumina–titania coatings were obtained by multi-chamber gas-dynamic accelerator (MCDS). The ceramic composite was prepared with Al_2O_3 and 50%Ti powder by solid state mixing route.

2. Experimental procedure

The composition of powder AMPERIT® 740.0 Al_2O_3 (d(0.1): 6.6 μm, d(0.5): 62.7 μm, d(0.9): 123, 4 μm) and titanium PTS-2 (Russia) (d(0.1): 11.29 мкм, d(0.5): 48.63 мкм, d(0.9): 91.31 мкм) (Fig. 1) was used to deposit a dense layer upon the plate of 30 × 30 × 5 (mm) on aluminium alloy AD31 substrate. The raw material powders consisted mainly of Al_2O_3 (γ-Al_2O_3, α-Al_2O_3, SiO_2) and Ti with a hexagonal lattice structure ($a = b = 2.94$ Å, $c = 4.68$ Å) (Al_2O_3: Ti wt ratio = 50:50) powders. The composite powder was prepared by solid state mixing route. Flat specimens of aluminium alloy AD31 (Fe-0.35 Cr-0.06 Cu-0.10 Mg-0.05 Ti-0.15, all in wt%) were used as substrates, and they were sand-blasted by an alumina grits 25A F360 prior to spraying.

In the present study, a multi chamber, vertically mounted detonation sprayer (MCDS) [8] with a barrel length of 500 mm was employed to the deposit of the alumina–titania coatings. The characteristic feature of MCDS is that the powder is accelerated by using the combustion products, which are formed in the MCDS chambers and are converged before entering the nozzle, where they interact with the two-phase gas-powder cloud [9,10]. The alumina–titania coatings have been prepared with a frequency of 20 Hz of the snake. Speed of moving was 2500 mm/min, distance from the sample was 60 mm. A barrel with a throat diameter of 16 mm was adopted.

The microstructural features of the powders and coatings were examined with the help of scanning electron microscope Quanta 200 3D (SEM) fitted with an energy dispersion X-ray spectroscopy and the phases were found by X-ray diffraction Rigaku Ultima IV. Microhardness was measured using a DM-8B (Affri) tester with a load of 50 g and a loading time of 10 s, and porosity was determined by analysing images photographed by optical microscope.

* Corresponding author.
E-mail address: kovaleva_m_g@mail.ru (M. Kovaleva).

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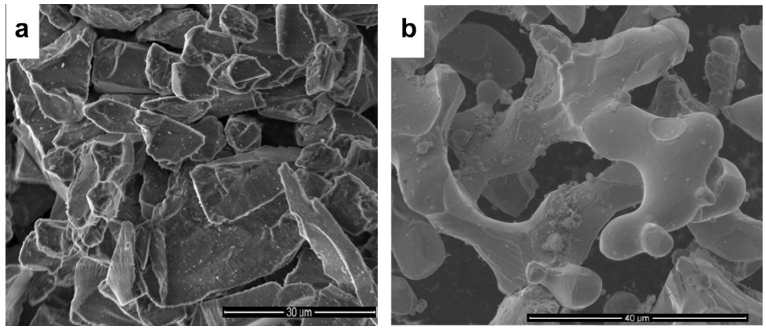
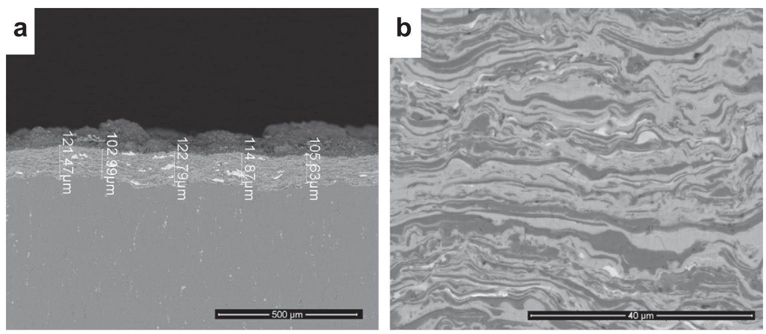
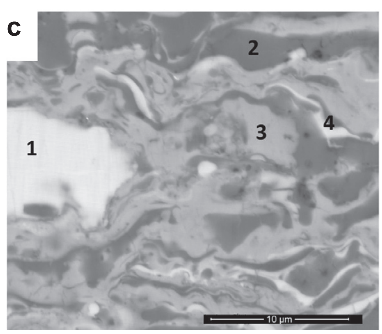


Fig. 1. SEM images of AMPERIT®740.0 Al_2O_3 (a) and titania powder PTS-2 (b).





d

Point	Element, wt%		
	O	Al	Ti
1	33.21	7.52	59.27
2	38.83	34.25	26.92
3	35.09	28.12	36.79
4	28.6	4.08	67.32

Fig. 2. SEM micrographs (a–c) and elemental composition (d) of alumina–titania coating layer.

3. Results and discussion

Thickness of the obtained coatings was varied and within the range from 100 to 125 µm, which resulted from the assumed investigated. The porosity of the alumina–titania coatings was 0.35 ± 0.05%. The coating (Fig. 2) shows a very dense microstructure consisting of well-flattened particles, which indicates that the most of the powder particles were melted before deposition. The obtained coating consists of remelted splats "flattened powder particles", small amount of porosity and unmelted particles.

The alumina–titania coatings exhibited a high hardness of about 1073 ± 152 $HV_{0.05}$. The hardness variation along the coat thickness is not uniform which may be attributed to the phase composition of the coating and due to the size of the indentation marks produced at 50 g, the measurements performed in the vicinity of the substrate are increasingly affected by the latter.

4. Conclusions

It was established that MCDS has provided the conditions for formation of a dense alumina–titania coating layer with porosity below 0.35% and microhardness of 1073 ± 152 $HV_{0.05}$. Results of this work open up new prospects for further elaboration of new technologies to making alumina–titania coating which can enhance properties of aluminium alloy surface.

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