Nanostructured surfaces

Investigation of oxide nano-layers formation on the NiAl-15wt.%TiB_2 composite material surface at high-temperature oxidation in air

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Under the conditions of aggressive action of gas flows of fuel combustion products on the surface of turbine blades it is necessary to combine their high-temperature strength and high heat resistance of the surface [1].

The development of composite materials in the "intermetallic-refractory compound" systems is one of the up-to-date trends in designing of novel materials aimed at operating under conditions of significant loads at high temperatures. In this work, as a matrix for such a composite material, nickel aluminide (NiAl) was selected which is widely used for deposition of protective coatings on the parts of aerospace engineering and power machine building, including components of gas-turbine installations and multi-aimed rocket engines [2-4]. However these materials are not practically used in high temperature frictional assemblies because of their intense plastic deformation over 550°C [5]. To be used under conditions of intense wear in a broad temperature range (to 1000°C), intermetallics require dispersion strengthening with the hard refractory inclusions.

In the present work the titanium diboride was chosen as a strengthening component for NiAl in view of its high hardness and wear resistance. Before we have been established that the introduction of titanium diboride into an intermetallic matrix leads to the increasing of the plastic deformation resistance of the obtained composite material in the process of high-temperature tribo-testing [6]. The aim of this work was to investigate the behavior of the compact NiAl-15 wt.% TiB_2 composite at high temperature in air and to establish the mechanism of its oxidation.

The developed materials are aimed at applying in the high temperature friction assemblies. The effect of the exposition time (1 min, 90 min) for high temperature (1000°C) oxidation of the NiAl-TiB_2 composite material in air on the structure, phase composition and intensity of oxide nano-layers formation on the composite surface has been studied. The selective oxidation was observed. The initial composite structure was composed of a matrix from NiAl intermetallic containing regularly distributed grains of TiB_2 titanium diboride. After oxidation of the composite on the NiAl matrix the continuous dense films were formed which correspond to the complex Al_2O_3 oxides and $AlBO_2$ borate, whereas on the refractory TiB_2 grains the volumetric globule-like Ti(Al)O and TiO_2 oxides appeared. To determine the relationship between the thicknesses of the oxides formed after oxidation, AES-analysis was used. The thickness of oxide layers on the matrix was established, it is equal to 80 nm, while that on the TiB_2 grains was equal to 560 nm. Therefore the intensity of oxide formation on boride grains is by seven times higher than that on the intermetallic matrix. These oxides can be used as solid lubricants and promote an increase of the wear resistance of materials.

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