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Tribological characteristics of self-lubricating systems with PVD coated TiB_2/Ti composites

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Tribological systems working under high operating temperatures up to 1000°C have recently received a great deal of attention. The aim of the project was to develop novel self-lubricating (self-lub) concepts to control friction in the range of 300°C to 1000°C through the double-lubrication approach i.e. lubricious substrate and lubricious coatings. The paper presents high temperature tribological behavior of TiB_2-based ceramic composites with self-lub PVD coatings.

Keywords: PVD coatings, self-lubricating systems, high temperature tribology, Spark Plasma Sintering

1. Introduction

The fundamental process of this self-lubrication mechanism is in situ formation of lubricous intermediate tribofilms [1]. On the base of existing knowledge, it is very difficult to predict the behavior of newly developed materials or multifunctional coatings being implemented into a heavily loaded tribo-systems, operating at high temperature. Tribological systems working at the range of 400-1000°C, which is considered as elevated or high temperature (HT) conditions, have not received a sufficient attention, mainly because of the processes such as accelerated oxidation, softening, potential phase transformation and creep, which, while being negligible in room temperature (RT), may play a dominant role at elevated temperature. Also, their synergies and antagonisms with wear are very complexed. The presented research focus on testing novel self-lubricating materials and coatings which are able to reduce friction and wear.

2. Methods

2.1. Coatings
Various coatings intended for high temperature applications were considered and tested. The following coatings: AlCrN, TiN-TiCrN-AlCrN-AlCrTiN/Si_3N_4, TiN-TiCrN-AlCrN-AlCrTiN/Si_3N_4-AlCrTiSiN+gradON, and TiN-TiCrN-AlCrN-AlTiCrN were investigated. The deposited PVD coatings properties were characterized by determining thickness, hardness, adhesion, GDOES profiles, and microstructure examination.

2.2. Substrates
For study the TiB_2/Ti composites were selected. They show superior high temperature properties in comparison to the most of nowadays bulk materials. TiB_2/Ti composites were manufactured by Spark Plasma Sintering (SPS). Samples were produced from a 50-50 wt.% ratio mixture of pure Ti and TiB_2 powders. Samples were sintered by SPS at the pressure of 50 MPa, using heating speed of 100°C per min. and with two maximum process temperatures: 1250°C and 1450°C, selected as a results of preliminary testing. Special finishing procedure was elaborated to obtain the a surface with required roughness (Ra = 0.080 ± 15 μm).

2.3. Test methods
SRV reciprocating sliding test machine suitable to perform tribological tests at the temperature up to 1000°C was used for tribological evaluation of developed TiB_2-based ceramic composites for HT tribo-applications with PVD coatings. Surface was observed using SEM and green light interferometry. EDS technique was employed for detection of the changes in the worn surface.

3. Results and discussion

One of the main challenges of the HOTselflub project was the development of TiB_2-based ceramic composites for HT tribo-applications with self-lub coatings. Tribological tests of elaborated systems were performed at wide range of temperatures from RT up to 1000°C. The results of the research and analysis showed a great potential of PVD coatings on TiB_2/Ti substrates subjected to wear by friction at high temperature. The results of surface analyses of wear tracks indicated that, at higher temperatures, oxidation is a very important factor influencing the wear resistance. The advantage of the coating revealed at high temperatures (600°C, 750°C) is the formation of "complex oxides" in the friction contact. Oxide layers (Al_2O_3 and Cr_2O_3), created at high temperature, is a barrier for further oxidation of the coating, and provides a lower coefficient of friction and high resistance to wear. To explain the mechanisms of the oxides action, further work will be conducted with the use of among others the x-ray diffraction.

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5. References

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