Low-cycle micro-impact tests of multilayer composite coatings

Jolanta Krupa[1)*], Sławomir Zimowski[1)], Grzegorz Wiązania[1)],

[1)] AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Mickiewicza Av. 30, 30-059 Krakow, Poland
*Corresponding author: krupa@agh.edu.pl

The main purpose of this study was to investigate the destruction mechanism of anti-wear thin coatings exposed to multicycle micro-impacts. Appearance of first crack is a predictor of the formation of subsequent spalling and chipping of the coating so it is crucial to recognize this phenomenon in detail. The low-cycle impact tests were used to observe and describe the places where the first cracks and their propagations occurred. Detailed analysis of coating failure with the use of 3D optical profilometer and microscopes technique is the solid basis for computer modeling of the coatings micro-impact wear.

Keywords (from 3 to 5 max): microimpact test, surface fatigue, multilayer coatings

1. Introduction

The phenomenon of micro-impact surface cracking can be observed in many machines' parts which are exposed to multi-cycle loads e.g. cold working forming tools, cutting edges of milling heads In order to increase the durability of such parts, manufacturers are increasingly willing to deposit hard coatings on the working surfaces and their properties are still under investigation [2]. Detailed investigation on the location and form of cracks in coatings subjected to low-cycle micro-impact fatigue was the basis for the analysis of the failure mechanism.

2. Methods

The subject of this study were three anti-wear coatings: multilayer titanium / titanium nitride coating ((Ti/TiN)×8), simple TiN coating and simple DLC coating deposited by PLD method on austenitic steel substrate. The micromechanical properties such as hardness and elastic modulus of the coatings were determined. The micro-impact fatigue tests of the coatings were performed on laboratory stand called "Impact Tester"[1] presented in Fig. 1.

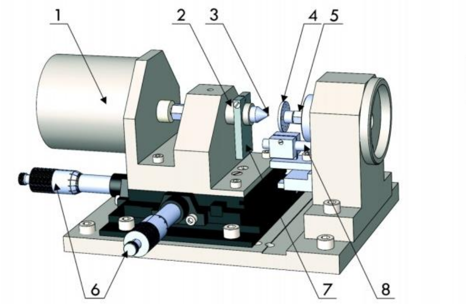
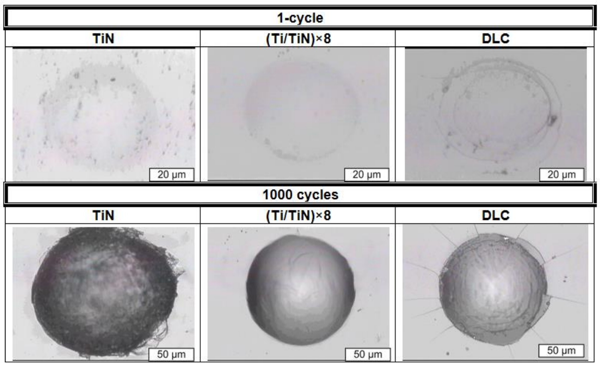


Figure 1: Impact Tester scheme: 1- inductor, 2- head, 3- indenter, 4- sample holder, 5- force sensor, 6- micrometer screws, 7- mirror, 8- optical displacement sensor

Each of the samples have been subjected to 1-, 10-, 50- 100-, 500- and 1000-cycle micro-impact tests by 0,2 mm of radius diamond ball with 4 N load. After experiments the surface of the craters formed in coatings have been observed using a light optical microscope. The results of microscope investigation, are shown in Table 1. A specific craters have been observed after each test in the place of indentations. The most important aspect of this study was to identify the places where the first coating's cracks appeared and how these cracks propagate in subsequent test. Detailed investigation on the location and form of cracks in coatings subjected to low-cycle micro-impact fatigue was the basis for the analysis of the failure mechanism. Additionally, selected samples were examined under the SEM microscope to control whether the complete detachment of the coating occurs.

Table 1: Images of surfaces with craters formed in coatings after a certain number of cycles



3. Discussion

The applied research methods made it possible to determine the radius of affected area on each coating, as well as length of radial cracks which were the most important factor in description of wear mechanism. Characteristic damage of the coating surface, such as after micro-impact fatigue tests, can also be observed after a single indentation.

The multi-layer structure of the coating (Ti/TiN)×8 ensures its highest resistance to fatigue wear compared to single coatings. The metallic titanium interlayers accumulate cracking energy and block the propagation of these cracks.

4. References

[1] Rakowski W., et al.,Micro-impact cracking of tribological coatings, Tribologia (2015) 145–157

[2] Zha X., et al., "Investigating the high frequency fatigue failure mechanisms of mono andmultilayer PVD coatings by the cyclic impact tests",Surface & Coatings Technology, 344, 2018,689-701.