Triboscopy of Amorphous Carbon Films

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This work expands the use of triboscopy for tribological data of amorphous carbon films. Firstly a classification procedure for different features apparent in the triboscopic images is introduced. Then the improved possibilities for debris detection and differentiation between changes on the counter body versus changes on the sample with this classification are described. Furthermore the detectability of stick-slip by observing the acceleration progression in triboscopic images is demonstrated.

Keywords (from 3 to 5 max): triboscopic images, DLC, ta-C, a-C, vacuum

1. Introduction

Tetrahedral amorphous carbon (ta-C) has been shown to exhibit exceptionally low friction and wear under dry sliding in the presence of water vapor as well as acceptably low friction and wear in the presence of inert gases. It is known that these properties deteriorate rapidly under vacuum conditions with decreasing pressure.

Triboscopy comprises techniques for the simultaneous temporal and spatial visualization of the evolution of tribosystems with high resolution, most often the evolution of friction [1].

For a better understanding of ta-C wear mechanisms under vacuum and dry conditions we further developed triboscopic imaging in regards to these systems. With this methodology different kinds of ta-C(:X) coatings were compared and, in addition, a categorization of artifacts in triboscopic images was established.

2. Methods

The carbon coatings used ranged from a-C to doped and undoped ta-C. The samples were prepared by LaserArc-PVD. All measurements were carried out with a custom-built ultra-high vacuum tribometer in ball-on-disc configuration with 1 kHz logging rate which supports reciprocating and rotating measurements. The environments used were dry and humid air, nitrogen, and vacuum up to 10^{-8} mbar.

The transformation of the raw measurement data to the triboscopic images was performed with a custom Python program.

3. Discussion

The observed artifacts were grouped into four classes: Uniform, Random, Cycle-persistent, and Position-persistent. Examples are given in Figure 1. From there different wear mechanisms were identified which manifested in the different features. E.g. abrasion of the counter body coating results in a friction drop which is persistent in cycle. "Random" spikes in friction can be attributed to debris in the contact from the abrasion.

By plotting the absolute value of the acceleration (Figure 2) one can visualize stick-slip behavior with stick and slip resulting in sudden high deceleration and acceleration, respectively.

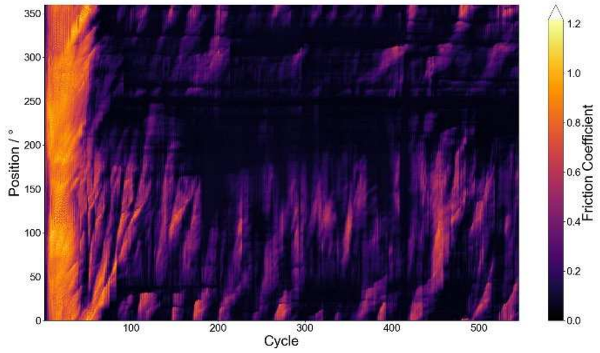

Figure 1 Triboscopic image of rotational experiment of ta-C-steel contact at 10^{-1} mbar demonstrating two features: running-in ("Persistent in cycle") and dragged-along debris from abrasion ("Random")

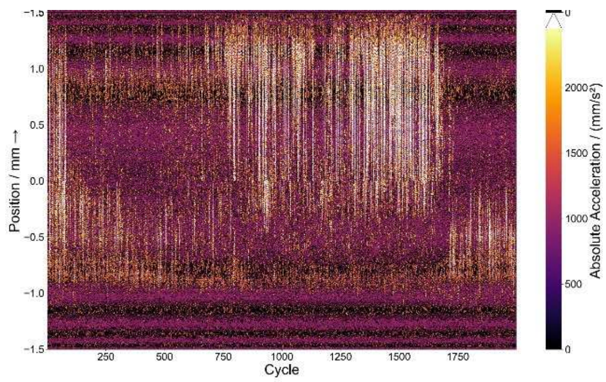

Figure 2 Triboscopic image of the absolute value of acceleration demonstrating the detection of stick-slip behavior

4. References

[1] M. Belin and J.M. Martin, Triboscopy, a new approach to surface degradations of thin films, Wear, 156 (1992) 151-160.

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