Insights into Solid Lubrication Processes of DLC Films thanks to Analytical Tribology

Antoine Normant[1,2], Jules Galipaud[1,3], Frédéric Dubreuil[1], and Julien Fontaine*[1]

[1]Laboratoire de Tribologie et Dynamique des Systèmes – CNRS : UMR5513, Ecole Centrale de Lyon, CNRS – France

[2]Laboratoire de Mécanique des Contacts et des Structures – CNRS, Institut National des Sciences Appliquées (INSA) - Lyon – France

[3]Matériaux, ingénierie et science – CNRS, Institut National des Sciences Appliquées (INSA) - Lyon – France

Abstract

Diamond-Like Carbon coatings may behave as very good solid lubricants, providing a good combination of tribological environment and coating composition is ensured. For instance, highly hydrogenated amorphous carbon (a-C:H) films may lead to super low friction regime ($\mu < 0.01$) under ultra-high vacuum, at least for a limited time. What are the tribological phenomena that allow for such performance, and what brings an end to this unique regime?To answer such questions, a traditional approach consist in performing some surface analysis after the experiments, inside and outside the wear tracks. These analyses are frequently morphological, structural or chemical, sometimes mechanical. While these informations are paramount for the understanding of the surface degradations during sliding, they don't provide information about the respective roles of these degradation on the evolution of the tribological response of the contact.In this work, we use a high resolution environment-controlled tribometer, based on a six axes force sensor, to probe the tribological response of a steel pin / a-C:H film contact, either by crossing existing wear tracks or by shifting the tracks to slide on pristine surfaces. This original approach helps understanding the respective role of surface modifications on the a-C:H coated flat or on the facing steel pin on the achievement of superlow friction. These experiments are combined with more traditional analytical means, like in situ XPS, AES and REELS analyses or ex situ SEM or AFM observations.The growth of a carbon-rich tribofilm on the steel counterpart appears necessary, but not sufficient to reach superlow friction. Changes on the topography and chemistry of the a-C:H film seems also paramount, with a smoothening of the a-C:H asperities and an increase of the sp2 Carbon content. The respective role of these phenomena on the solid lubrication process of a-C:H film will be discussed.

*Speaker