ATOMIC-SCALE MECHANISMS OF SUPERLUBRICITY WITH DIAMOND-LIKE CARBON COATINGS AND SILICON-BASED CERAMICS

G. Moras [a*], T. Kuwahara [b], T. Reichenbach [a], M. Moseler [a]
*gianpietro.moras@iwm.fraunhofer.de
[a] Fraunhofer IWM, MikroTribologie Centrum μTC,
Wöhlerstraße 11, 79108 Freiburg, Germany
[b] Osaka Metropolitan University,
Gakuen-cho, Nakaku, Sakai, Osaka 599-8531, Japan

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ABSTRACT
Achieving stable superlubricity (i.e., a friction coefficient lower than 0.01) in plain bearings would considerably help to increase energy efficiency in many technical applications in a simple and cost-efficient way. Four Fraunhofer institutes came together in the SupraSlide project with this objective. Within the project, multiple systems were identified that yield stable macroscopic superlubricity over a wide range of operation conditions. Among the most promising material systems are diamond-like carbon, silicon nitride and silicon carbide lubricated by organic liquids such as glycerol and polyethylene glycol. The mechanisms underlying superlubricity are diverse and depend on the specific system.

In this contribution, I will attempt to rationalise the results of the tribological tests and present the superlubricity mechanisms that we have identified so far by combining atomistic simulations and experimentals. We focus specifically on superlubricity in boundary lubrication and on two possible microscopic mechanisms. The first mechanism is reminiscent of structural superlubricity and involves direct contacts between passivating amorphous carbon tribofilms. We show that these, partially aromatic [1, 2], carbon tribofilms can form by tribochemical reactions of molecules like glycerol at ta-C/ta-C [1] and Si_3N_4/Si_3N_4 [3] interfaces. Alternatively, passivating carbon tribofilms can be transferred from suitably designed a-C:H coatings onto Si_3N_4 surfaces [4]. A second possible mechanism involves tribological interfaces in which a thin liquid film separates the two surfaces. In this context, I will show the results of molecular dynamics simulations on systems lubricated with water or mixtures of water and glycerol and discuss critical aspects regarding the thickness and nanoscale structure of the lubricant film.

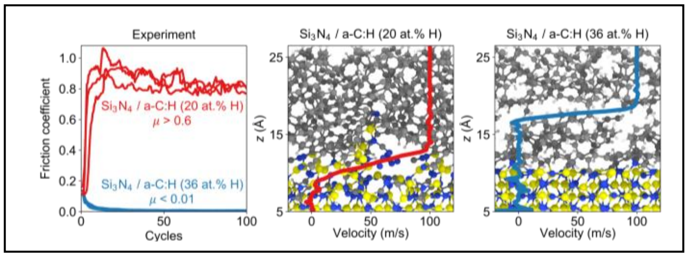

Fig.1 Superlubricity of Si_3N_4 paired with a-C:H coatings in UHV. While a 36 at. % H in a-C:H yields superlow friction (blue), friction and wear are high for a-C:H with 20 at. % H (red). Atomistic simulations unveil that stable transfer film formation only occurs above a critical amount of hydrogen in a-C:H. Reprinted with permission from Ref. [4]. Copyright (2024) American Chemical Society.

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