Investigation of contact friction on material surfaces nanostructured with fs-lasers

Kevin Lubig[1], Ebru Cihan[2], Eric Rahner[1], Stephan Gräf[1], Enrico Gnecco[2,3], and Frank A. Müller[1]

[1]Friedrich Schiller University Jena, Otto Schott Institute of Materials Research (OSIM), Löbdergraben 32, D-07743 Jena, Germany
[2]Institute for Materials Science and Max Bergmann Center for Biomaterials, TU Dresden, Budapester Straße 27, D-01069 Dresden, Germany
[3] M. Smoluchowski Institute of Physics, Jagiellonian University, ul. Łojasiewicza 11, PL-30-348 Krakow, Poland
*Corresponding author email: Kevin.Lubig@uni-jena.de

Sliding friction is a fundamental subject in Materials Science, as well as in everyday life. Friction can be very useful, as one realizes when driving on an icy road. On the other hand, it is usually an annoying phenomenon, as proven by uncountable examples in mechanical engineering. Together with energy losses, friction can lead to abrasive wear, and ultimately to failure of mechanical components potentially causing more damage than fracture and plastic deformation.

The systematic investigation of friction processes requires surfaces with well-defined topographical properties. In this context, ultra-short pulse lasers (fs-lasers) established as a versatile tool for the precise engineering of nano- and microstructures. They can be used to fabricate laser-induced periodic surface structures (LIPSS, ripples) on large surface areas with a high degree of regularity. These surfaces offer excellent model systems for the detailed analysis of functional surface properties (e.g. tribology) and their influencing parameters.

In the present study, LIPSS were fabricated with different period, orientation and complexity on different types of materials (metals, graphite, polymers). The structured substrates were used to investigate the relationship between the material and geometric properties of two solid surfaces during friction under dry conditions. This analysis was carried out at the nano-level using advanced atomic force microscopy (AFM) equipped with colloidal probes (diameter $\leq$ 15 µm) as sliding objects. The properties of the nanostructured surfaces including their morphology, stiffness and adhesion were analyzed for different material pairings before contact and the development of friction over time under different load conditions and measurement directions (relative to surface structures) was evaluated. The obtained results served as input for modelling approaches based on available contact theories. The findings can be useful in micromachining and, beyond engineering applications, as well as in the interpretation of signals acquired by artificial tactile sensors.

References:

[1] E. Cihan et al., Dynamics of sliding friction between laser-induced periodic surface structures (LIPSS) on stainless steel and PMMA microspheres, *ACS Appl. Mater. Interfaces* **15** (2023) 14970-14978.