MM 51: Mechanical properties II

Time: Thursday 10:15–11:45 Location: TC 010

MM 51.1 Thu 10:15 TC 010

Velocity strengthening friction significantly affects interfacial dynamics, strength and dissipation — •Robert Spatschek[1], Marc Weikamp[1], Efim Brener[2], Yohai Bar-Sinai[3], and Eran Bouchbinder[3] — [1]Max-Planck Institut für Eisenforschung, Düsseldorf — [2]Peter-Grünberg-Institut, Forschungszentrum Jülich — [3]Chemical Physics Department, Weizmann Institute of Science, Rehovot, Israel

Frictional processes are a natural feature of our daily life, yet their dynamics are not well understood. Recent experimental data have revealed that velocity strengthening friction, where frictional resistance increases with sliding velocity over some range, is a generic feature of such interfaces. Moreover, transitions between velocity weakening and strengthening regimes have recently been linked to slow fronts ("slow earthquakes"). Here we elucidate the importance of velocity strengthening friction by theoretically studying variants of a realistic friction model, all featuring identical logarithmic velocity weakening at small sliding velocities, but different high velocity behaviour. We find a dramatic influence on front velocity, event magnitude, dissipation and radiation rates. Additionally, we show that velocity strengthening can give rise to a new kind of frictional instability for sliding on a rigid substrate, which is related to interval vibrational high frequency excitations in the sliding object.

MM 51.2 Thu 10:30 TC 010

microstructure evolution of brass alloys under dry reciprocating tribological loading — •zhilong liu[1], philipp messer[1], peter gumbsch[1,2], and christian greiner[1] — [1]Karlsruhe Institute of Technology, Institute for Applied Materials, Kaiserstrasse 12, 76131 Karlsruhe, Germany — [2]Fraunhofer IWM, Woehlerstrasse 11, 79108 Freiburg, Germany

Correlating a material's microstructure with its friction and wear properties is a central question in tribology. Still, there are many open questions concerning the mechanistic understanding of the microstructure evolution under a tribological load.

Different brass alloys with zinc contents between five and 36% in contact with silicon nitride were used as model tribosystems. Between these alloys, the stacking fault energy varied by more than a factor of five. Starting with an annealed microstructure, we systematically varied the sliding distance and followed the evolution of the microstructure by scanning electron and focused ion beam microscopy. A tribologically deformed layer was observed after the tests, whose thickness increased with the sliding distance. Comparing the results for different brass alloys and those for high-purity copper, an effect of increasing zinc content was observed.

A long term goal of this study is to formulate a mechanistic model description for the microstructural changes in tribological contacts, including the influence of different stacking fault energies in face-centered cubic metals. This might allow for materials with tailored microstructures combing low friction forces and small wear rates.

MM 51.3 Thu 10:45 TC 010

Nanotribology induced Microstructure Evolution in Pearlite — •Caroline Fink, Steffen Brinckmann, Sunmi Shin, and Gerhard Dehm — Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf, Germany

Tribology has long been understood as a hierachical phenomenon: nanoscale asperities exist on mesoscale asperities which exist on macroscopic asperities. Hence, tribology is a multiscale mechanism that spans multiple orders of length scales. We focus on tribological experiments at the micro- and nanoscale in iron alloy micro-structures to fundamentally understand tribology. The aim of this study is to upscale these findings to the friction and wear behavior at the macroscale. We prepare pearlite samples with varying carbon content and highlight the preparation requirements for experiments at the nanoscale. Single stroke scratches are performed and used to provide microstructure specific friction coefficients and scratch depths. Post-deformation investigations by atomic force microscopy, scanning electron microscopy and confocal microscopy reveal the microstructure dependent pile-up and real contact area. Cross-sections by focused ion beam milling show the nanotribology induced sub-surface microstructure which we relate to the cemetite lamellae orientation and spacing. Finally, we will highlight the influence of the nanoscale counter-body shape on the wear resistance and the friction coefficient.

MM 51.4 Thu 11:00 TC 010

Roughness and Microstructure Development during Nanotribology in Austenite — •Steffen Brinckmann, Caroline Fink, and Gerhard Dehm — Max-Planck-Institut für Eisenforschung, Düsseldorf, Germany

Materials wear is the collective contact on a number of hierarchical length scales. The macroscopic surface has microscopic surface roughness which itself has an almost atomistic surface roughness superimposed. We study wear at the microscopic lengthscale by using a single hard asperity and study the deformation of the flat Austenite steel. Single stroke experiments reveal that the plasticity and roughness are determined by the local grain orientation. Moreover, the symmetric scratch loading can lead to unsymmetrical slip patterns, when comparing both sides of the scratch. We find that analytical equations based on the Hertz solution and the Hardness equation predict the elastic and plastic scratch depth for multiple orders of normal force, although both equations were developed for the static indentation loading and not the present dynamic scratch loading. Finally, we will discuss the formation of cracks and surface roughness in the scratch tracks. We close with a discussion on the addition of the plasticity induced surface roughness to the hierarchical length scales in tribology.

MM 51.5 Thu 11:15 TC 010

Investigation of VHCF behavior of an austenitic-ferritic duplex steel during insitu XRD measurements with different load amplitudes — •Anne K. Hüsecken[1], Marcus Söker[2], Ullrich Krupp[2], and Ullrich Pietsch[1] — [1]Universität Siegen, Siegen, Germany — [2]Hochschule Osnabrück, Osnabrück, Germany

The behavior of materials in the region of very high cycle fatigue (VHCF) is not known, yet. Nowadays, with the development of ultrasonic testing machines (BOKU Vienna), it is possible to reach the region over 10 million cycles within a few hours. One of these machines was directly mounted on the diffractometer at beamline BL 10 at DELTA in Dortmund, to investigate the behavior of single grains within the flat dogbone-shaped austenitic-ferritic duplex steel samples (1.4462) during the whole fatigue process of the sample. Therefore Rockingscans were performed after each fatigue step with different load amplitudes, analyse FWHM and peak positions. In former studies we already showed, that it is possible to analyse one single grain by this method [1]. We found, that some grains rotate or change their lattice orientations during fatigue [2]. The analysis and results of these XRD measurements will be presented.

[1] K.Istomin et al., Int. J. of Fatigue 66 (2014), 177-182.
[2] A.K. Hüsecken et al., Procedia Engineering 74 (2014), 53-56.

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