MM 70: Mechanical Properties II

Time: Thursday 17:00–18:15 Location: IFW D

MM 70.1 Thu 17:00 IFW D

The Origin of Microstructural Discontinuities underneath a Tribologically Loaded Surface — •Christian Greiner[1], Zhilong Liu[1], Reinhard Schneider[1], Lars Pastewka[1], and Peter Gumbsch[1,2] — [1]KIT, Kaiserstrasse 12, 76131 Karlsruhe — [2]Fraunhofer Institute for Mechanics of Materials IWM, Woehlerstrasse 12, 79108 Freiburg, Germany

Frictional loading of a metal surface induces microstructural changes underneath the surface. A typical tribo-induced microstructure displays distinct discontinuities parallel to the surface which separate the near surface layer from the bulk. By systematically decreasing the number of passes of a sapphire sphere sliding over high-purity copper, we find that the origin of the microstructural discontinuity is already laid after the first sliding pass even for very mild sliding conditions. A distinct dislocation structure is formed 100-150 nm under the surface. This distinct dislocation self-organization is attributed to a sign change in the stress field underneath the sliding indenter. The dislocation structure evolves into the known microstructural features with increasing number of sliding passes. Consequently, the microstructure and mechanical properties of the surface layer are determined in the very first loading pass. Control of the initial tribological loading could therefore be exploited to precondition interfaces for superior tribological properties.

MM 70.2 Thu 17:15 IFW D

Towards understanding fracture toughness experiments at the microscale — •Steffen Brinckmann and Gerhard Dehm — Max-Planck-Institut für Eisenforschung

Micrometer cantilever beams are frequently employed to determine the fracture toughness of (1) single phases in poly-phase materials as well as (2) particular grain boundaries. The determination of the mechanical properties mostly relies on the experimentally determined maximum force and analytical models which are build for brittle and isotropic materials. However, the vast majority of materials has a limited amount of plasticity and is anisotropic. Moreover, the cantilever width has an influence on the fracture toughness since the crack driving force is maximal in the beam center and plane-stress conditions apply at the beam surface. This contribution uses the results of more than a thousand 3D simulations and quantifies the influence of anisotropy, Poisson's ratio and beam geometry. At the end of the contribution, we discuss the influence of plasticity and its challenges. We give best-practice guidelines for microbeams and discuss the changes in fracture toughness, if guidelines cannot be fulfilled or if anisotropic materials are studied.

MM 70.3 Thu 17:30 IFW D

Hydrogen embrittlement of tungsten using deuterium plasma charging and microscale fracture experiments — •Xufei Fang[1], Marcin Rasinski[2], Arkadi Kreter[2], Dmitry Matveev[2], Rafael Soler[1], Steffen Brinckmann[1], Christoph Kirchlechner[1], Christian Linsmeier[2], and Gerhard Dehm[1] — [1]Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Strasse 1, 40237 Düsseldorf, Germany — [2]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung-Plasmaphysik, 52425 Jülich, Germany

Hydrogen embrittlement (HE) is the cause of widespread failure of engineering structures. In this work we report fracture toughness and indentation experiments to study the HE of tungsten. Micro-cantilevers with pre-notches were cut using a Focus Ion Beam into single large grains that were selected by using Electron Backscatter Diffraction. The samples with micro-cantilevers were charged with deuterium plasma (max ion flux 5.0E+21 m-2s-1) and were mechanically investigated. Micro-cantilever fracture experiments at different times (i.e. 5h, 24h, 72h) after plasma charging were carried out and compared to those of uncharged micro-cantilevers. Load-displacement curves and post-mortem scanning electron microscopy showed that both charged and uncharged cantilevers exhibit plastic deformation and a blunted crack tip with a trace of crack tip sharpening. We will discuss these findings, the evolution of the unloading-reloading stiffness and correlate them to the nanoindentation results to shed more light on the hydrogen effect on the mechanical properties of tungsten.

MM 70.4 Thu 17:45 IFW D

Microstructure evolution in pearlite during microscale wear experiments — •Caroline Fink, Steffen Brinckmann, and Gerhard Dehm — Max-Planck-Institut für Eisenforschung GmbH, 40237 Düsseldorf, Germany

We study friction and wear of a microasperity on a smooth surface to enhance the understanding of macroscopic friction. This study focuses especially on the tribologically induced microstructure evolution in pearlitic steel. The bulk pearlite is mechanically ground and polished to achieve a flat surface. Single microscratches are performed by a conical diamond tip of a few micrometer radius in a nanoindenter. After target preparation, the microstructure underneath the scratch is studied with scanning electron microscopy. We observed matrix grain refinement, lamellae fracture and bending. We further investigate the latter with cementite fracture toughness and bending experiments by using microcantilevers inside an in-situ nanoindenter. Furthermore we evaluate tribological surface layer formation via electron backscatter diffraction.

MM 70.5 Thu 18:00 IFW D

Rupture of graphene sheets with randomly distributed defects — •Samaneh Nasiri and Michael Zaiser — Department of Materials Science and Engineering, WW8-Materials Simulation, Friedrich- Alexander University Erlangen-Nürnberg, Fürth, Germany

We use atomistic simulation (molecular mechanics and molecular dynamics) to investigate failure of graphene sheets containing randomly distributed vacancies. We investigate the dependency of the failure stress on defect concentration and sheet size and show that our findings are consistent with the Duxbury-Leath-Beale (DLB) theory of mechanical or electric breakdown in random media. The corresponding distribution of failure stresses falls into the Gumbel, rather than the Weibull class of extremal statistics. By comparing molecular mechanics and zero-temperature molecular dynamics simulations we establish the role of kinetic energy in crack propagation and its impact on crack patterns emerging before sheet rupture.

Keywords: graphene; fracture; microcracks; disordered media; extremal statistics