MM 39: Mechanical properties I

Time: Thursday 16:15–18:15 Location: H6

MM 39.1 Thu 16:15 H6

Tribological performance of WC/C coatings on rough substrates — •Mikhail Kosinskiy[1], Yonghe Liu[1], Maik Gubisch[2], Lothar Spiess[2], and Juergen A. Schaefer[1] — [1]Institut für Physik und Zentrum für Mikro- und Nanotechnologien, Technische Universität Ilmenau, Germany — [2]Institut für Werkstofftechnik und Zentrum für Mikro- und Nanotechnologien, Technische Universität Ilmenau, Germany

The available measurements on the tribological behavior of WC/C multilayer coatings are mainly performed on atomically smooth Si surfaces. In this work, we study the influence of surface roughness on the friction and wear of WC/C coatings. Chromium steel samples cut from linear bearing were polished to surface roughness (Ra) in the range of 3 nm ˜ 700 nm, and subsequently deposited with 700 nm thick WC/C coatings. The measurements were performed by using a reciprocating microtribometer at different normal load and velocity in normal atmospheric conditions. As a comparison, bare samples (without coating) were also tested. We find a roughness, on which the coefficient of friction (COF) is minimum for bare samples, but is maximum for coated samples. The reduction of COF by applying the coating is ˜200%.

MM 39.2 Thu 16:30 H6

Evaluating creep behaviour of thin wall structures at high temperatures - method and first results — •Rainer Hüttner, Rainer Völkl, and Uwe Glatzel — Rainer Hüttner, Metals and Alloys, University of Bayreuth, Ludwig-Thoma-Straße 36b, D-95447 Bayreuth, Germany

The knowledge of creep behaviour of structural materials for high temperature applications is prerequisite for life-time predictions. In order to optimize both the cooling efficiency and the weight of fast rotating turbine blades a general trend to reduce the wall thicknesses of the hollow investment castings is observed. This work deals with a method for evaluating creep behaviour of thin wall structures. The test equipment uses resistive heating to achieve fast heating and cooling rates. The environment during testing can be changed to vacuum, inert gas or air in order to determine in-situ oxidation effects on creep behaviour. Creep strain is measured with accuracy better than 0.1% by a non-contacting image vision technique. A video extensometer and the software SuperCreep is used to reach this high resolution. The principles of this technique and first results will be presented.

MM 39.3 Thu 16:45 H6

Atomistic simulations of the dislocation motion in Fe with solute atoms — •Christopher Kohler and Siegfried Schmauder — Institut für Materialprüfung, Werkstoffkunde und Festigkeitslehre, Universität Stuttgart, Pfaffenwaldring 32, 70569 Stuttgart, Germany

Solute atoms in metals lead to a strengthening effect by impeding the motion of dislocations. This results from a short-range interaction of the solutes with the dislocation cores as well as from a long-range interaction of a distribution of many solutes with the dislocations. Molecular dynamics (MD) simulations with empirical interatomic potentials, e.g. EAM potentials, are a suitable method to model the dislocation-solute interaction at the atomic scale. In this talk, results of MD simulations of solid-solution strengthening in α-Fe are presented. The gliding of dislocations under the influence of an applied shear stress and at different temperatures is studied for random distributions and specific configurations of solute atoms. The effect of solute atmospheres around the dislocation core is also investigated.

MM 39.4 Thu 17:00 H6

Local stress incompatibilities as source of dislocation nucleation and damage — •Markus Welsch, Michael Marx, and Horst Vehoff — Universität des Saarlandes, Werkstoffwissenschaft und Methodik, Postfach 15 11 50, 66041 Saarbrücken, Deutschland

During high cycle fatigue of polycrystalline materials local inhomogeneities cause localized additional stresses. For instance due to elastic anisotropy orientation differences at grain boundaries work as additional driving forces for damage mechanisms. This was shown by experiments and simulations in a previous work, where cracks initiated exactly at grain boundaries with the highest incompatibility stresses calculated by finite element method (FEM). In the further work these experiments are extended to local plastic deformation at higher loads. The stress distribution of an elastic anisotropic material is calculated by FEM. This calculation uses the 3-dimensional arrangement of the grain boundaries and the orientation of the grains determined by electron backscatter diffraction. In the range of beginning elastic-plastic deformation, the local additional stresses are absorbed by the formation of dislocation structures (DS). DS and persistent slip bands develop, which also act as preferential crack initiation sites. These DS are examined by electron channelling contrast imaging. During fatigue in the grains of different orientation strongly varying DS are formed. But also inside these grains the arrangement of the structures is not uniform. Near grain boundaries seams with different DS are generated. The influence of incompatibility stresses on DS and their influence on crack initiation and propagation are presented in this work.

MM 39.5 Thu 17:15 H6

Simulation der Materialermüdung durch einen neuen, granularen Ansatz — •Judith Fingerhuth[1], Matz Haaks[1], Gunter Schütz[2] und Karl Maier[1] — [1]Helmholtz-Institut für Strahlen- und Kernphysik, Rheinische Friedrich-Wilhelms-Universität Bonn, Nußallee 14-16, D-53115 Bonn — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich

In einem neuen Ansatz wird die Ermüdung eines Metalls mit einem granularen, mesoskopischen Modell simuliert. Der Kristall wird als regelmäßige Anordnung von Kristallkörnern betrachtet, deren in der Realität sehr komplexe Eigenschaften auf einige wenige skalare Parameter reduziert werden: Korngröße, Orientierung und E-Modul. Die sich während der Ermüdung erhöhende Versetzungsdichte wird dabei durch einen Schädigungsparameter repräsentiert. Informationen über die Schädigung werden durch lokale Übergangsfunktionen übertragen. In einer ersten Implementierung wird das Verhalten von Nickel im einachsigen Zug-Druck-Versuch schon teilweise wiedergegeben.

MM 39.6 Thu 17:30 H6

Artificial crack initiation and investigation by focused ion beam microscopy — •Wolfgang Schäf, Michael Marx, and Horst Vehoff — Universität des Saarlandes, Werkstoffwissenschaft und Methodik, Postfach 151150, D 66041 Saarbrücken

The influence of the microstructure on fatigue crack growth is of interest in respect to increasing the lifetime of construction materials. A method to investigate the interaction of grain boundaries with short cracks is to introduce micro notches by Focused Ion Beam (FIB) milling in a given distance to a grain boundary. During cyclical loading, a microcrack initiates at the notch tips. The interaction between crack and grain boundary can be studied by measuring the crack velocity in respect to the distance from the grain boundary. A three dimensional tomography of the crack plane and the grain boundary can be revealed by FIB tomography with a resolution comparable to a scanning electron microscope. By this technique, it is possible to visualize the crack plane twist and tilt at a grain boundary. Further, the influence of carbide precipitates on crack growth in a nickel based superalloy was examined. It is shown that this method can also be applied to pure nickel and duplex stainless steel.

MM 39.7 Thu 17:45 H6

Change of deformation mechanism in sub-microcrystalline PED nickel during cyclic loading — •Lutz Hollang[1], Ellen Hieckmann[2], and Werner Skrotzki[1] — [1]Institut für Strukturphysik, Technische Universität Dresden, 01062 Dresden — [2]Institut für Angewandte Physik, Technische Universität Dresden, 01062 Dresden

Sub-microcrystalline (smc) nickel produced by pulsed electrodeposition (PED) was cyclically deformed at room temperature at different plastic strain amplitudes $10^{-4} \leq \epsilon_{pa} \leq 10^{-2}$. The standard plastic strain rate $\dot{\epsilon}_p = 2 \cdot 10^{-5} s^{-1}$ was repeatedly varied to determine the derivative $(\partial\sigma_a/\partial \ln \dot{\epsilon}_p)_T$ as a function of the stress amplitude σ_a. Both, σ_a and $(\partial\sigma_a/\partial \ln \dot{\epsilon}_p)_T$ are rather high in the as-prepared state, but significantly decrease during cycling at constant $\epsilon_{pa} \geq 2.5 \cdot 10^{-4}$ until the specimens exhibit strain localization leading to fracture. X-ray diffraction and transmission electron microscopy reveal that the smc PED nickel cannot resist to ongoing cyclic deformation at room temperature. Already at relatively small ϵ_{pa} dynamic recovery and grain growth processes substantially diminish the internal stresses and

transform the as-prepared smc microstructure into a recovered microcrystalline state. The $(\partial\sigma_a/\partial \ln \dot{\epsilon}_p)_T$ vs. σ_a relationship indicates a gradual change of the rate-controlling process from dislocation–grain boundary interaction at the beginning of cyclic deformation to classical dislocation–dislocation interaction immediately before fracture.

MM 39.8 Thu 18:00 H6

Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS -ICP-MS) in the high resolution study of trace elements distribution patters in selected materials — Watling John[1] and •Chaudhri . Anwar[2] — [1]Centre for Forensic Sciences, Uni. of Western Australia, Perth — [2]Klinikum Nürnberg-Süd, 90471 Nürnberg

One of the major problems for identifying the chemical reasons for fracture or failure of metals and metal alloys is the lack of accurate chemical data for metal concentrations across the failure site. Most modern analytical techniques require the use of relatively large sample masses to ensure accurate multi-element data. The fact that large samples have to be taken often means that there is a significant contamination of the relevant sample with material spatially associated with, but not causative in, the failure. This fact excludes the use of chemical analytical techniques to ascertain the causes of any failure. Techniques such as Scanning Electron Microscopy coupled with Energy Dispersive X-ray Analysis (SEM - EDXRA) can provide micron resolution analytical data. However, the detection limit of the technique is large and as such may not be sufficiently sensitive to identify the true cause of failure. Detection limits of LA-ICP-MS, an analytical technique making use of laser light to ablate a solid sample matrix, are in the sub parts per million level.To illustriate the usefulness of the technique some examples of elemental distributions in different materials are presented.