MM 55: Topical session (Symposium EPS and MM): Mechanical Properties at Small Scales

Layered Structures

Time: Thursday 11:45–13:00 Location: H 0106

Topical Talk MM 55.1 Thu 11:45 H 0106

Deformation mechanism map of Cu/Nb nanoscale metallic multilayers as a function of temperature and layer thickness — •Jon Molina-Aldareguia[1], Jeromy Snel[1], Miguel Monclús[1], Nathan Mara[2], Irene Beyerlein[3], and Javier Llorca[1,4] — [1]IMDEA Materials Institute, c/Eric Kandel 2, 28906 Getafe (Madrid), Spain — [2]University of Minnesota, Minneapolis, MN 55455-0132 — [3]University of California, Santa Barbara, CA 93106-5070 — [4]Universidad Politécnica de Madrid, 28040 Madrid, Spain

The mechanical properties and deformation mechanisms of Cu/Nb nanoscale metallic multilayers (NMMs) manufactured by accumulative roll bonding (ARB) are studied at 25 °C and 400 °C. Cu/Nb NMMs with individual layer thicknesses between 7 and 63 nm were tested by in-situ micropillar compression inside a scanning electron microscope. Yield strength, strain-rate sensitivities and activation volumes were obtained from the pillar compression tests. The deformed micropillars were examined under scanning and transmission electron microscopy in order to examine the deformation mechanisms active for different layer thicknesses and temperatures. A remarkable transition in deformation mechanism occurred at 400 °C as the layer thickness decreased, from dislocation glide to dislocation climb at interfaces, which resulted in temperature-induced softening. A deformation mechanism map, in terms of layer thickness and temperature, is proposed from the results obtained in this investigation.

MM 55.2 Thu 12:15 H 0106

Cu/Fe Nanocomposites produced by Accumulative Roll Bonding — •Maher Ghanem, Benoit Merle, Heinz Werner Höppel, and Mathias Göken — Friedrich-Alexander-Universität Erlangen-Nürnberg, Department Werkstoffwissenschaften, Lehrstuhl Allgemeine Werkstoffeigenschaften (WW I); Martensstraße 5, 91058 Erlangen, Deutschland

The accumulative roll bonding (ARB) process has been applied to produce multilayered composites with layer thickness in the range of submicron to nanometer. Such multilayered composites show a strong increase in strength as the grain sizes are refined down to the submicron range. CuSn4/Fe multilayered nanocomposites with alternating layers of CuSn4 and Fe (99.88%) were roll bonded with 50% reduction and a post heat treatment at 400 °C following each pass. The rolling was repeated at least 10 times in order to achieve a layer thickness less than 1 um. Microstructure and texture of the nanocomposites were evaluated using backscatter electron (BSE) imaging and electron backscatter diffraction (EBSD), respectively. Mechanical properties were investigated through tensile and nanoindentation tests in order to observe the changes in the mechanical properties both locally and globally as the number of ARB passes increased. Furthermore, the layer interfaces of the nanocomposite at different rolling cycles were analyzed using Atom Probe Tomography (APT).

MM 55.3 Thu 12:30 H 0106

Severe Microscale Deformation of Pearlitic Steel During Tribology — •Steffen Brinckmann[1], Caroline Fink[1], Haleh Taghinejadi[2], and Gerhard Dehm[1] — [1]Max-Planck-Insitut für Eisenforschung, Düsseldorf, Germany — [2]University of Cambridge, Cambridge, UK

Tribology at the macroscale is determined by the interaction of the microasperities that result in the wear of the counter surface and the subsurface microstructure evolution. State of the art macroscale tribology experiments investigate the convoluted interaction of a thousands of asperities and phases. We focus on a single asperity with micrometer size and study how the pearlite microstructure is deformed. The pearlite consists of hard cementite lamellae and soft ferrite matrix, each of which has a unique deformation mechanisms. We study both deformation mechanisms and discuss how the alignment of the microstructure influences the residual deformation, the wear of the microstructure. We determine the cementite deformation mechanisms and quantify the grain refinement in the ferrite matrix as a function of the wear loading. The development of a microstructure based understanding of the wear mechanisms would allow in the future to design wear resistant surfaces for engineering components.

MM 55.4 Thu 12:45 H 0106

Local Fatigue Testing by Dynamic Micropillar Compression of ARB Processed Bimodal Copper Sheets — •Sebastian Krauss, Mathias Göken, and Benoit Merle — Department of Materials Science and Engineering, Institute I, Friedrich-Alexander-University Erlangen-Nürnberg, Germany

Local fatigue experiments on microscale testing geometries offer the opportunity to isolate microstructure contributions to mechanical deformation behavior. In contrast to macroscopic fatigue testing, it is therefore possible to characterize the effect of individual features of interest independently. In this study Accumulative Roll Bonding (ARB) processed copper sheets with a bimodal microstructure were analyzed. Micropillars were milled by FIB structuring, producing testing geometries in individual layers of the material. Due to the bimodal microstructure, the different microsamples in each layer show varying grain sizes, which results in a change of the respective fatigue properties. Additionally micropillars at the interface were prepared to study interface contributions on the fatigue behavior. The investigations were executed by a novel approach that combines dynamic nanoindentation and micropillar compression. With this technique the high cycle fatigue range is easily accessible for microscale samples. Observation of the underlying deformation processes was performed by recording SEM micrographs of the deformed samples. Continuative investigations were realized by FIB milling of the deformed samples to create a cross-sectional view of the deformed microstructure.