MM 8: SYM Micro- and Nanomechanics II

Time: Monday 14:45–17:00 Location: H16

MM 8.1 Mon 14:45 H16

Superplastic deformation of ultrafine-grained Mg-alloys produced by micro-alloying and equal channel angular extrusion — •Florian H. Dalla Torre[1], Anja Hänzi[1], Maciej Krystian[2], Peter J. Uggowitzer[1], and Jörg F. Löffler[1] — [1]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zurich, Wolfgang-Pauli-Str. 10, 8093 Zürich, Switzerland — [2]ARC Seibersdorf Research GmbH, Materials Research , Materials Micro-/Nanoengineering

The 'grain growth restriction'- concept via the addition of elements such as Zn, Ca, and Zr to Mg was used to cast and extrude two alloys with grain sizes of <5 and <10 micrometers, respectively. In combination with equal channel angular extrusion processing, the grain size was further reduced. Mechanical testing showed a substantial increase in ductility at room temperature compared to that in conventional Mg alloys. In addition, the high strain rate sensitivity, in combination with the effect of micro-alloying elements on stabilizing the grain size yields beneficial properties for superplastic micro- and net-shape-forming processes. The dependence of texture, grain size and twinning is discussed, together with their influence on temperature-dependent deformation mechanisms.

MM 8.2 Mon 15:15 H16

Deformation Processing of Massive Nanostructured Materials — •Gerhard Wilde — Institut für Materialphysik, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

One way to obtain massive specimens, e.g. of pure fcc or hcp metals with extremely small average grain sizes is given by repeated cold-rolling, as shown recently for several pure metals. In fact, even intermetallic alloy phases with rather high melting temperatures could be processed successfully, such that a residual grain size of less than 100 nm was obtained. This new method extends the range of microstructures that are accessible by severe plastic deformation treatments towards smaller grain sizes. In contrast to nanocrystalline materials obtained by powder methods such as inert gas condensation, the material synthesized by cold rolling contains a high density of dislocations as well as significant residual strain in the nanosized grains. In addition, to synthesis, recent results related to the underlying deformation mechanisms of the nanocrystalline material containing lattice defects as well as new measurements of the mechanical properties hardness and strength in dependence of the grain size and will be discussed for pure fcc model systems. These first results indicate significant improvements concerning properties and performance that can be gained through nanostructuring by applying advanced deformation processing treatments. The ongoing work is supported by the Deutsche Forschungsgemeinschaft.

15 min break

MM 8.3 Mon 16:00 H16

Strain-Rate-Sensitivity of nanocrystalline Ni investigated with nanoindentations and compression tests — •Johannes Mueller and Mathias Göken — Institut für Werkstoffwissenschaften, Universität Erlangen-Nürnberg

The deformation behaviour of nanocrystalline materials is known to be dependent of the deforming strain rate. The reason for this strain-rate-sensitivity is subject to ongoing research. An technologically interesting field is coating of components with thin layers. Nanoindentation is a suitable method to characterise mechanical properties of those thin coatings. However the data obtained by nanoiondentation is not trivially comparable to those obtained by macroscopical method. In this work the strain-rate-sensitivity of nanocrystalline electrodeposited nickel is studied using compression tests and nanoindentations using different indenter shapes. Explanations for the differences found, are discussed.

MM 8.4 Mon 16:15 H16

A nanomechanical approach to hydrogen embrittlement of metals — •Afrooz Barnoush and Horst Vehoff — Saarland University, Department of Materials Science, Bldg. D22. P.O. Box 151150, D-66041 Saarbruecken, Germany

New nanomechanical testing methods like nanoindentation allows us to study mechanical properties of materials in nano scale where the plastic deformation could be studied in detail. This was the motivation for a nanomechanical approach to hydrogen embrittlement of metals using a novel in-situ electrochemical nanoindentation setup. In this work nanoindentation has been used to study the effect of hydrogen on deformation of small volumes for nickel and copper single crystals as two metals with different sensitivity to hydrogen embrittlement. Nickel is known to be prone to hydrogen embrittlement where there is no hydrogen embrittlement for copper. Electrochemical hydrogen charging reduces the load at which dislocations are nucleated (pop-in load) in nickel, while this results in no observable change in the pop-in load of copper single crystal as expected. The experimental results are analyzed using a thermodynamic model for homogenous dislocation nucleation. Based on these analyses, the activation energy for the onset of plasticity is believed to be reduced by the dissolved hydrogen in crystal lattice.

MM 8.5 Mon 16:30 H16

Plasticity of thin polycrystalline metallic films: a discrete dislocation dynamics approach — •Jochen Senger[1], Daniel Weygand[1], Oliver Kraft[1,2], and Peter Gumbsch[1,3] — [1]IZBS, Universität Karlsruhe (TH) — [2]IMF II, Forschungszentrum Karlsruhe — [3]IWM, Fraunhofer Institut für Werkstoffmechanik, Freiburg

Recent experimental observations (Spolenak et al, PRL 90, 096102, 2003) showed that the stress distribution in polycrystalline thin metal films upon thermal cooling or heating can be quite inhomogeneous. Stress variations were observed between grains and even within grains. To study such stress distributions, a parallel discrete dislocation dynamics (DDD) tool is employed, based the tool described in Weygand et al., Mod. Sim. Mater. Sci. Eng. 10 (2002) 437. The parallelization is achieved using OpenMP for shared memory platforms. The concept is based on a common data structure, where the individual calculation tasks are distributed among the CPUs. The main computational tasks, the interaction calculation between dislocation and the evaluation of the boundary conditions are performed on multiple CPUs and a very good scaling is achieved. The parallelized version of the DDD code is applied to the simulation of the small scale plasticity of polycrystalline thin films. The dislocation microstructure evolution and the resulting stress distributions are analysed and compared experiments and single grain simulations. If the calculated stresses of the multi grain simulations are averaged over areas corresponding to the experimental resolution, excellent agreement is found for stress amplitudes in simulation and experiment.

MM 8.6 Mon 16:45 H16

Modulated lateral force microscopy: an AFM tool for analysis and modification of polymer surfaces — •Heinz Sturm — BAM VI.25, Federal Institute for Materials Research, Unter den Eichen 87, D-12205 Berlin

Scanning Probe Microscopy, here Scanning Force Microscopy in the contact mode, is widely used not only to examine the 3-dimensional surface topography, but also to evaluate nano-mechanical surface properties. This contribution focuses on the tip-surface interaction due to a shear deformation, i. e., friction. During forward and backward scan with a given scanning (shear) velocity, the cantilever lateral bending (torsion) is a measure for the lateral force. Unfortunately, both scan directions must be acquired and subtracted to separate the topography cross-talk from the friction image. Superimposing a lateral displacement between tip and surface via a dither piezo, the shear deformation is sinusoidally modulated. Images of amplitude and phase shift of the dynamic cantilever torsion within a frequency range from 30 kHz up to 60 MHz are presented. Due to the fact that friction is always a dynamic process, we prefer to call this technique "Modulated Lateral Force Microscopy" (MLFM) instead of just "Dynamic Friction Microscopy". The dependence of the modulated friction from the normal force between tip and lever can be described with the Johnson-Kendall-Roberts model.