MM 18: Mechanical Properties I

Time: Tuesday 14:00–15:30 Location: IFW B

MM 18.1 Tue 14:00 IFW B

Mechanical properties and plastic anisotropy of aluminium laminates produced by accumulative roll bonding (ARB) — •Paul Chekhonin[1], Benoit Beausir[1], Juliane Scharnweber[1], Carl-Georg Oertel[1], Werner Skrotzki[1], Heinz Werner Höppel[2], and Jörn Jaschinski[3] — [1]Institut für Strukturphysik, Technische Universität Dresden — [2]Lehrstuhl Allgemeine Werkstoffwissenschaften, Universität Erlangen-Nürnberg — [3]Institut für Leichtbau und Kunststofftechnik, Technische Universität Dresden

Aluminium sheets with layers of different purity (99.999 and 99.5) have been produced by ARB. The tensile strength and Lankford parameter as a function of the number of ARB cycles are measured by tensile testing. ARB increases the tensile strength significantly. The planar anisotropy decreases with the number of ARB cycles while the normal anisotropy reaches a plateau after 2 cycles. The results will be compared with those of ARB aluminium with a purity of 99.5.

MM 18.2 Tue 14:15 IFW B

Inhomogeneity of texture and microstructure in copper deformed by ECAP — •Christine Tränkner, Robert Chulist, Benoit Beausir, and Werner Skrotzki — Institut für Strukturphysik, Technische Universität Dresden, 01062 Dresden, Germany

Polycrystalline copper of high purity was deformed by equal channel angular pressing (ECAP) at room temperature using routes A, B_C and C with up to 4 passes. Local textures were measured by high-energy synchrotron radiation. For route B_C this was done along 3 lines in the cross section from the top to the bottom of the billets; for routes A and C along 1 line in the middle of the cross section. Using orientation imaging by electron backscatter diffraction microstructure analysis was performed in the cross and in the longitudinal section.

Texture gradients in normal direction of the billets were found for all routes, while in addition a texture gradient in transverse direction was found for route B_C. The texture is compared with that of simple shear. Different microstructures for route A, B_C and C were detected in the cross and in the longitudinal section. They are presented for 4 passes and discussed with regard to the change of shear plane position when rotating the sample between two passes. The average grain size after 4 passes is approximately 1 μm for all routes. Grain refinement is explained by continuous dynamic recrystallization.

MM 18.3 Tue 14:30 IFW B

Shear band formation in sub-microcrystalline Ni — •Benoit Beausir[1], Lutz Hollang[1], Suhash Ranjan Dey[2], Ellen Hieckmann[3], and Werner Skrotzki[1] — [1]Institut für Strukturphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Department of Materials Science and Engineering, Indian Institute of Technology Hyderabad, Ordnance Factory Estate, Yeddumailaram-502205, Andhra Pradesh, India — [3]Institut für Angewandte Physik, Technische Universität Dresden, 01062 Dresden, Germany

The stability of sub-microcrystalline nickel produced by pulsed electrodeposition without any additives was investigated during cyclic deformation at very high plastic strain amplitude of 1% at room temperature. The initial microstructure having an average grain size of 160 nm in the growth plane and a weak <110> fibre texture along the growth direction undergoes considerable grain growth during cyclic loading without significant changes in texture. After a certain number of loading cycles the specimen suddenly developed a single macro shear band. The shear band appeared in the tensile half cycle under 45° to the loading axis and acts as crack starter. Investigations in the scanning electron microscope using electron backscatter diffraction revealed that the main macro shear band consists of relaxed grains elongated along the shear plane displaying a texture induced by shear. The texture in the shear band was reproduced with the viscoplastic self-consistent polycrystal model using {111}<110> slip systems. Detailed investigations of the surrounding of the macro shear band reveal the existence of a large number of regularly spaced micro shear bands.

MM 18.4 Tue 14:45 IFW B

Properties of non-equilibrium grain boundaries in UFG nickel produced by severe plastic deformation — •Gerrit Reglitz, Sergiy Divinski, Harald Rösner, and Gerhard Wilde — Institute of Materials Physics, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Ultra-fine grained (UFG) materials produced by severe plastic deformation (SPD) have become an important target of research due to their improved properties and the promise they hold with respect to novel applications. It has been suggested by several authors that so-called non-equilibrium grain boundaries in SPD processed materials are largely responsible for their properties. These non-equilibrium grain boundaries contain a high density of extrinsic (excess) dislocations and an increased excess free volume. The existence and the properties of non-equilibrium grain boundaries can be studied in great detail by grain boundary diffusion measurements, because such non-equilibrium grain boundaries should represent ultra-fast diffusion paths in comparison to conventional, relaxed high-angle grain boundaries in coarse grained materials.

Grain boundary self-diffusion in UFG Ni prepared by Equal Channel Angular Pressing (ECAP) has been measured by applying the 63Ni radioisotope in combination with the parallel sectioning technique. The results indicate the existence of ultra-fast diffusion paths. The influence of the ECAP processing parameters will be presented. The origin of the ultra-fast diffusion pathways and their possible relation to non-equilibrium grain boundaries will be discussed.

MM 18.5 Tue 15:00 IFW B

Controlling the strength of nanocrystalline metals and alloys: On the role of the grain boundary relaxation state — •Jonathan Schäfer, Alexander Stukowski, and Karsten Albe — TU Darmstadt, Darmstadt, Germany

Plastic deformation in various nanocrystalline metals and their alloys is studied by means of atomic scale computer simulations.

The distribution of solutes is equilibrated in nanocrystalline model structures of different grain sizes and compositions using a combination of Monte-Carlo and molecular dynamics methods. The resulting samples are deformed under uniaxial load. The role of grain boundary relaxation is analyzed in detail by comparing chemically and structurally relaxed samples with model structures that were only structurally relaxed. The relaxation state of the grain boundary is measured by means of the atomic free volume. The defect evolution within the grains of our nanocrystalline model structures is monitored, using a novel dislocation extraction algorithm.

The main goal of this work is to make a connection between the atomistic configuration within the microstructures and the characteristics of the observed stress-strain behaviour.

The simulations reveal that the relaxation state of the GBs is of great importance for the maximum strength in the case of all studied material systems and grain sizes. The (chemical) equilibration is proven to raise the barrier for GB mediated processes. Also in the case of grain sizes, where the major carrier of plastic deformation is dislocation slip, the relaxation state of the GB is shown to have a significant effect.

MM 18.6 Tue 15:15 IFW B

Tilings as models for auxetic cellular structures — •Holger Mitschke[1], Jan Schwerdtfeger[2], Vanessa Robins[3], Carolin Körner[2], Robert F. Singer[2], Klaus Mecke[1], and Gerd E. Schröder-Turk[1] — [1]Theoretische Physik I, Universität Erlangen-Nürnberg — [2]Insitute of Advanced Materials and Processes, University of Erlangen-Nuremberg — [3]Applied Maths, School of Physical Sciences, Australian National University, Australia

In most auxetic materials, the negative Poisson's ratio is a consequence of the geometry of the microstructure. This motivates the search for auxetic structures in archives of mathematical models, such as planar tiling or spatial periodic networks. Here we study the deformation of planar tilings, interpreted as skeletal structures. Our numerical study of their deformations reveals several new auxetic structures and examples with different degrees of freedom, i.e. rigid, unique-flexible or flexible with several deformation modes. In the latter case, we show that the conservation of initial symmetries are a possibility to enforce a unique deformation corresponding to the energy minimum of an energy functional, e.g. given by harmonic angular springs at the vertices. Furthermore we show that elastic cellular structures, built by Ti-6Al-4V selective electron-beam melting rapid prototyping precisely on the basis of the newly found auxetic skeletal structures, possess the same deformation behaviour, namely a negative Poisson's ratio. Finally, the analysis of repositories of three-dimensional tilings or networks (such as `www.epinet.anu.edu`) is equally possible and has the potential to yield conceptually new truly-3D auxetic deformation mechanisms.