MM 34: Topical Session Bulk Nanostrucured Materials VII - Mechanical Properties II

Time: Wednesday 11:45–13:00 Location: H 0107

MM 34.1 Wed 11:45 H 0107

The Effect of Severe Plastic Deformation on the Fatigue Behaviour of an Austenitic Stainless Steel — Oliver Renk, •Anton Hohenwarter, and Reinhard Pippan — Erich-Schmid-Institut, Leoben, Österreich

Ultra-fine grained and nanocrystalline materials produced by severe-plastic deformation represent a new class of materials as their properties can be varied over a wide range. Larger specimens now permit, the investigation of mechanical properties of these metals. However, only a few studies on structural materials, such as austenitic steels, exist. In this work the fatigue behaviour of a severely deformed 316L austenitic steel was investigated. By different processing parameters and a post heat treatment, four different ultra-fine grained and nanocrystalline structures were obtained, with grain sizes from 50 nm to 800 nm. The analysis of these different structures should allow a better understanding of the microstructural influence on the fatigue properties. Mechanical tests were conducted on the different severely deformed structures as well as on the coarse grained starting material to show the effect of severe plastic deformation. The main advantage of the ultra-fine grained austenitic structures compared with conventional heavily cold-rolled austenitic steels is, apart from their higher stress levels, their excellent cyclic stability. Fractographic Investigations showed completely different damage and fracture mechanisms of the ultra-fine grained and nano structures. Shear banding and strain localisation in these shear bands play a major role for the damage process during cyclic as well as monotonic loading.

MM 34.2 Wed 12:00 H 0107

Fatigue and crack propagation in SPD Cu with regard to microstructural stability — •Jelena Horky, Golta Khatibi, Brigitte Weiss, and Michael Zehetbauer — Physics of Nanostructured Materials, Faculty of Physics, University of Vienna, 1090 Wien, Austria

For broad commercial applications of SPD nanomaterials not only enhancements in strength and ductility but also in fatigue and crack propagation are important. Therefore, this work aimed to investigate these properties in HPT (High Pressure Torsion)-processed Cu of two different purities. Besides high cycle fatigue (HCF), the main focus was laid on crack propagation. In case of cyclic loading, not only the thermal stability of HPT Cu but also its microstructural one is highly affected by the purity. Concerning high cycle fatigue, the reduced stability of a homogeneously nanostructured high purity Cu leads to grain coarsening and deteriorated fatigue strength. However, in case of very small load amplitudes and the presence of a crack, grain coarsening leads to retardation of crack growth, in contrast to a bimodally structured high purity Cu which shows a stable microstructure during crack propagation. Moreover, low purity HPT Cu which shows no grain coarsening during HCF, coarsens in the vicinity of a growing fatigue crack, indicating that crack propagation rates are determined by various, partly interdependent factors like purity, grain size, initial strength of the material and thermal stability of the microstructure.

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MM 34.3 Wed 12:15 H 0107

Creep measurements in HPT-processed copper having ultrafine grain size — •Jörn Leuthold[1], Matthias Wegner[1], Anantha Padmanabhan[2], Sergiy Divinski[1], and Gerhard Wilde[1] — [1]Institute of Materials Physics, University of Muenster, Germany — [2]School of Engineering Sciences & Technology, University of Hyderabad, India

In materials processed by severe plastic deformation, the presence of a high defect density in the form of dislocations, twins, high and low angle grain boundaries (GB) and their distribution affects the plastic deformation when a shear stress is applied. With a decrease in grain size into the sub-micrometer range, a dislocation-based deformation mechanism becomes increasingly unfavorable. Therefore GB diffusion and sliding account for the rate controlling deformation process even at low homologous temperatures, i.e. the creep resistance is significantly reduced. Regardless of the rate controlling physical mechanism, the "power law" is used to describe steady state, uniaxial deformation in the high stress, low homologous temperature regime. For this study copper samples were prepared by high pressure torsion and cut into a dog bone shape to perform isothermal tensile creep experiments. From load jump experiments, the stress exponent, activation energies for rate controlling flow and the strain rate values at different stresses and temperatures are obtained. Microstructural characterization in terms of nanoindentation, electron backscatter diffraction of as prepared and creep deformed specimens, changes in hardness, grain size distribution and texture are related to the observed activation energy.

MM 34.4 Wed 12:30 H 0107

Pressure dependence of plasticity in nanocrystalline Pd90Au10 — •Christian Braun, Manuel Grewer, and Rainer Birringer — Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus D2.2, 66123 Saarbrücken

The recently introduced miniaturisation of the shear-compression-specimen [1] allows the mechanical testing of small samples such as inert gas condensed nanocrystalline materials via dominant shear-deformation. By means of a variation of the shear-angle, it is possible to vary the shear-compression-ratio and the hydrostatic pressure P in the deformation zone. The analysis of the pressure dependence of plastic flow relies on two prominent parameter, the pressure activation volume Δv_P and the Mohr-Coulomb coefficient μ. For nc Pd90Au10-samples with an average grain diameter of about 10 nm, we determined Δv_P to 1-2 b^3, where Δv_P is given as $\Delta v_P = \frac{\partial \sigma}{\partial P} \Delta v_\sigma$ and Δv_σ is the shear activation volume obtained from stress-strain-curves taken at different strain rates [2]. Applying the Mohr-Coulomb yield criterion, we deduced a friction coefficient μ in the order of 0.1-0.2 which is comparable to values obtained for a variety of bulk-metallic-glasses [3]. Analogies between the deformation behaviour of bulk-metallic-glasses and nanocrystalline materials in the limit of small grain sizes will be discussed.

[1] M. Ames, J. Markmann, R. Birringer, Mater. Sci. Eng. A 528, 526 (2010), [2] A.S. Argon, Strengthening Mechanisms in Crystal Plasticity, OUP (2007), [3] Z.F. Zhang, J. Eckert, L. Schultz, Acta Mater. 51, 1167(2003)

MM 34.5 Wed 12:45 H 0107

Fracture behavior of copper: Ultrafine-grained vs. coarse-grained microstructure — •Anton Hohenwater and Reinhard Pippan — Erich Schmid Institute of Materials Science, Austrian Academy of Sciences, A-8700 Leoben, Austria

The fracture behavior of ultrafine-grained copper produced by high pressure torsion was evaluated by means of elasto-plastic fracture mechanics. The fracture toughness was quantitatively measured by JIC as a global measure by recording the crack growth resistance curve. As a local fracture parameter the initiation toughness in terms of the crack opening displacement (CODi) was evaluated by using an automatic fracture surface analysis system. The results show a remarkably high global fracture toughness, JIC, but at the same time a low fracture initiation toughness, Ji. In this contribution reasons for the large difference between these two parameters will be discussed and a comparison of the fracture mechanical performance of ultrafine-grained with coarse-grained copper will be given.