MM 60: Nanomaterials IV - Deformation and mechanical properties

Time: Thursday 15:45–17:00 Location: IFW B

MM 60.1 Thu 15:45 IFW B

Deformation of nanoporous gold: the importance of topology — •Bao-Nam D. Ngo[1,3], Karsten Albe[2], and Jörg Weissmüller[1,3] — [1]Institut für Werkstoffforschung, Werkstoffmechanik, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany — [2]Technische Universität Darmstadt, Fachbereich Material- und Geowissenschaften, Fachgebiet Materialmodellierung, Darmstadt, Germany — [3]Institut für Werkstoffphysik und Werkstofftechnologie, Technische Universität Hamburg-Harburg, Hamburg, Germany

We present a molecular dynamics study on the influence of the topology on the mechanical properties of nanoporous gold. Following a suggestion by N. Huber et al. [1], we study a highly symmetric diamond-like structure and compare it to a disordered structure, both having comparable relative density, feature size, and surface area. The random sample shows zero lateral expansion to a certain point under compression and noticeable lateral contraction in tension. Plasticity happens immediately upon compression, followed by strain hardening of material due to dislocation activity. In line with continuum modeling, the symmetric structure shows appreciable lateral strain in both compression and tension. It also shows clear elasticity before yielding, with similar elastic modulus in both test modes. Appreciable dislocation activity in compression is observed only at very large strain. Other relevant mechanical properties are also investigated, suggesting that topology can strongly affects nanoporous mechanical behavior.

[1] N. Huber et al., Scaling Laws of Nanoporous Metals under Uniaxial Compression; in preparation (2013).

MM 60.2 Thu 16:00 IFW B

Glass-like characteristics of grain-boundary (GB) mediated plasticity in nanocrystalline (NC) PdAu alloys — •Andreas Leibner, Manuel Grewer, Christian Braun, Jonas Heppe, and Rainer Birringer — Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus D2 2, 66123 Saarbrücken

There is ample evidence that at the low end of the nanoscale (<10nm), plastic deformation of NC metals manifests among other mechanisms in shear transformations (ST) that are confined to the core regions of GBs. On the other hand ST are the generic flow defect of metallic glasses. Therefore, it is in order to compare the deformation parameters of NC metals with appropriate counterparts in bulk metallic glasses (BMG).

Here we present a systematic investigation on the elastic properties and plastic behavior of NC PdAu with varying Au concentration and compare our results with solid solution strengthening / softening effects so far observed in nanoscale materials. However, drawing a conclusion, we emphasize an analogy to the deformation behavior in BMG.

MM 60.3 Thu 16:15 IFW B

A comparative study of the mechanical behavior of nanocrystalline metals and bulk metallic glasses using shear compression specimen — •Christian Braun, Manuel Grewer, and Rainer Birringer — Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus D2.2, 66123 Saarbrücken

Polycrystalline metals at the low end of the nanoscale with grain sizes of 10 nm or less are characterized by a grain boundary volume fraction of at least 30%. Grain boundary deformation modes similar to shear transformations in bulk metallic glasses (BMGs) may therefore play a non-negligible role in the mechanical behavior of nanocrystalline (nc) metals. In fact, a couple of similarities between this two material classes have been observed, e.g. comparable values for the shear activation volume, activation energy or Mohr-Coulomb friction coefficient. In BMGs, increasing load causes percolation of shear transformations that leads to shear band formation and concomitant strain localization followed by catastrophic failure. On the other hand, in nc metals the deformation seems to be carried by shear transformations distributed across the network of grain boundaries. Instead of catastrophic failure through shear banding, nc metals at the low end of the nanoscale even exhibit strain hardening. We will discuss in detail the similarities and dissimilarities of the deformation behavior of nc Pd90Au10 and the BMG Pd40Ni40P20 under the same loading conditions.

MM 60.4 Thu 16:30 IFW B

Ultra high stresses in thin Nb-H films — •Magnus Hamm, Vladimir Burlaka, Stefan Wagner, and Astrid Pundt — Universität Göttingen, Institut für Materialphysik, Friedrich-Hund-Platz 1, 37077 Göttingen

Mechanical stress influences different material properties. Some examples are the change of the critical temperature [1], the change of the electromotoric force [2] or changes in the energy-band structure [3].For thin metal films clamped to a rigid substrate, hydrogen absorption on interstitial lattice sites results in compressive mechanical stress. Up to -3.4 GPa have been measured by Laudahn et al. for Nb-films.[4] While for low concentrations the stress increases linearly with the hydrogen content, the stress increase is reduced by the creation of dislocations, for higher concentrations. As suggested by Nörthemann et al.[5] the mechanical stress evolution depends on the film thickness: Below a critical thickness of the film the formation of dislocations even becomes energetically unfavorable. It is shown that below this critical thickness the stress increases to very high values. This observed stress change is reversible.

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[1] J. Weissmuller and C. Lemier, Philos. Mag. Lett. 80:6 (2000)
[2] R. Kirchheim, Acta metall. 1:34 (1986)
[3] R. People, IEEE J. Quantum Electron., 22:6 (1986)
[4] U. Laudahn et al., J. Alloys Compd. 293-295:20 (1999)
[5]K. Nörthemann and A. Pundt, Phys. Rev. B 78:1 (2008)

MM 60.5 Thu 16:45 IFW B

Processing of Ti/Al light-weight composite sheets via accumulative roll bonding and differential speed rolling — •Jan Romberg[1,2], Jens Freudenberger[1,3], Juliane Scharnweber[4], Tom Marr[1], Jürgen Eckert[1,2], Werner Skrotzki[4], and Ludwig Schultz[1,2] — [1]IFW Dresden, Dresden, Germany — [2]TU-Dresden, Institut für Werkstoffwissenschaft, Dresden, Germany — [3]TU-BA Freiberg, Institut fuer Werkstoffwissenschaft, Freiberg, Germany — [4]TU-Dresden, Institut für Strukturphysik, Dresden, Germany

Severe plastic deformation (SPD) techniques facilitate the generation of ultra-fine grained metals and, therefore, increase strength and ductility. Among the SPD techniques accumulative roll bonding (ARB) is the only one that facilitates the creation of semi-finished products of reasonable size. In addition, composite materials can be produced by means of ARB. The aim of this study is to create fine laminar Ti/Al composite sheets by means of ARB. Literature discusses the effect of differences in yield stress and presents opportunities of further processing in spite of necked Ti layers. However, previous research have not noticed that the only precondition to avoid necking is sufficient strain hardening. We discuss approaches to increase the strain hardening by means of intermediate heat treatment, the effect of increase of the strain rate and differential speed rolling. The effect of this means on grain size, strength and texture development is shown. It can be expected that further classes of composite materials and non equilibrium solid solutions will be created with the help of the presented results.