MM 55: Nanomaterials - Nanocrystalline & Porous Materials II

Time: Thursday 11:45–13:00 Location: H25

MM 55.1 Thu 11:45 H25

Structural and thermodynamic properties of severely deformed nickel — •Daria Prokoshkina[1], Anna Moros[1], Vladimir Popov[2], Gerhard Wilde[1], and Sergiy Divinski[1] — [1]Institute of Materials Physics, University of Münster, Germany — [2]Institute of Physics of Metals, Russian Academy of Science, Ekaterinburg, Russia

The effect of severe plastic deformation (SPD) on microstructure, thermodynamic and transport properties of Ni of 99.6 wt. % purity was investigated. The plastic deformation was realized via equal channel angular pressing (ECAP), high-pressure torsion (HPT) and by cold rolling (CR) to 80 %. The properties of ultrafine grained nickel prepared by room temperature deformation (ECAP, HPT, CR), warm deformation at 200°C (ECAP), and cold deformation at liquid nitrogen temperature (HPT) were compared. The influence of different deformation paths on the microstructure was studied by Scanning Electron Microscopy with Focused Ion Beam add-on. Differential Scanning Calorimetry was used to analyze the thermally induced defect recovery. Grain boundary diffusion measurements were used to characterize the kinetic properties of interfaces in deformed and annealed materials applying the radiotracer technique and the 63Ni radioisotope. The obtained results are discussed concerning the impact of the deformation pathway on the kinetic and microstructural properties.

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MM 55.2 Thu 12:00 H25

Molecular dynamics study of nanoporous gold deformation — •Bao-Nam D. Ngo[1,2], 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

Nanoporous gold made by dealloying is under discussion for applications in actuation, catalysis, and sensing. The material is also a model system for deformation processes in nanomaterials. While early experiments suggest that nanoporous gold is brittle, recent studies reveal its ductile behavior in compression test, with many striking observations, such as a yield strength lower than what is expected from scaling law, nearly zero transverse plastic flow, and extremely high strain hardening coefficients. Here, we report a molecular dynamics study of the deformation of nanoporous gold, focused on uniaxial compression tests. Computer samples are prepared by spinodal decomposition. In agreement with experiment, they show ductile behavior with low yield stress, very small transverse plastic strain, and an extended elastic-plastic transition region in the stress-strain curve. The underlying deformation mechanisms and dislocation activity are investigated.

MM 55.3 Thu 12:15 H25

Elastic and plastic behavior of nanoporous gold as a function of the surface state — •Nadiia Mameka[1], Jürgen Markmann[1,2], and Jörg Weissmüller[1,2] — [1]Helmholtz-Zentrum Geesthacht, Institut für Werkstoffforschung, Werkstoffmechanik, 21502 Geesthacht, Germany — [2]Technische Universität Hamburg-Harburg, Institut für Werkstoffphysik und -technologie, 21073 Hamburg, Germany

Nanoporous metal is a bicontinuous network of nanoligaments interpenetrated by an open pore space. It exhibits an extremely high specific surface area, which is accessible to electric signals, that afford the surface properties tuning. In this way, the macroscopic materials behavior can be reversibly modified. Here, we report an *in situ* study on mechanical properties of bulk nanoporous gold infiltrated with electrolyte. The metal-liquid interface properties were controlled via the electrode potential, E. This allowed reversible variations between 1) adsorbate-covered and bare or 2) electrically charged and charge-neutral surface states. The environmental control was implemented in a dynamic mechanical analyzer (DMA) and mechanical testing machine, and revealed large reversible cyclic changes of the effective elastic modulus and flow stress. The results advertize a role of two higher derivatives of the surface free energy function $\psi(E,e)$ where e denotes the strain. The parameter $\mathrm{d}^2\psi/\mathrm{d}e^2$ represents an excess elastic constant of the surface. The potential dependence of this behavior, probed in our DMA experiments, relates to the third derivative, $\mathrm{d}^3\psi/(\mathrm{d}e^2\mathrm{d}E)$. Our data present first evidence for this quantity and support the notion of tuning the elasticity and plasticity via the applied electric potential.

MM 55.4 Thu 12:30 H25

Synthesis of nanoporous gold for electrochemical actuators — •Yi Zhong[1], Jürgen Markmann[1,2], Hai-Jun Jin[3], and Jörg Weissmüller[1,2] — [1]Institut für Werkstoffforschung, Werkstoffmechanik, Helmholtz Zentrum Geesthacht, Geesthacht, Germany — [2]Institut für Werkstoffphysik und Technologie, Technische Universität Hamburg-Harburg, Hamburg, Germany — [3]Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences, Shenyang, P.R. China

Dealloying, an alloy corrosion process of gold alloys was used to fabricate nanoporous gold (npg) with a porosity up to 80 % and structural sizes, i.e. ligament diameters, down to a few nanometers. Particularly, the formation of macroscopic cracks has been investigated for two different starting alloy compositions, Au25Ag75 and Au25Cu75 which represent substitutional solid solutions with more or less identical atom size (Au-Ag) and very different atom size (Au-Cu). Apart from the dealloying potential, different pretreatments of the starting consequently provided completely different microstructural starting conditions and were compared with respect to their ability to suppress cracks in the resulting nanoporous structure. The resulting samples were crack-free with ligament sizes below 10 nm. Within different electrolyte environments, the amplitude of actuation of this npg could be tuned to values up to 0.89 %. Npg with such small ligament sizes are expected for application in electrochemical actuators of high functionality.

MM 55.5 Thu 12:45 H25

Diffusion-induced recrystallization in Si/Ge — •Michael Kasprzak, Sebastian Manuel Eich, Dietmar Baither und Guido Schmitz — Institut für Materialphysik, Westfälische Wilhelms-Universität, Münster

In size-mismatched thin film interdiffusion couples, Diffusion-Induced Recrystallization (DIR) appears rather than conventional Fickian interdiffusion. New grains formed in the diffusion zone reveal characteristic stepwise composition levels. Based on experiments with metallic thin films, we derived recently a quantitative model which combines thermo-elastic driving forces and grain boundary migration [1-3]. Observed concentration levels are such that the stress in front of the moving grain boundary reaches a maximum. This stress is rather high, close to the theoretical maximum strength of the material at the relevant temperature. In new experiments, we study this effect in semiconductor layers, Ge on Si, for the first time. Heat treatment was performed in two stages: first annealing at 650°C to crystallize the pure Ge layer; second annealing at higher temperatures to initiate interdiffusion. Transmission electron microscopy and energy dispersive X-ray spectroscopy show that new grains of characteristic composition are indeed formed towards the Ge side of the diffusion couple similar as previously observed with fcc metals. Characteristic concentrations are derived from XRD data and compared with the suggested model.

[1] Schmitz et al. Scr Mater 63 (2010) 484; [2] Kasprzak et al. Acta Mater 59 (2011) 1734; [3] Eich et al. Acta Mater 60 (2012) 3469