MM 52: Nanomaterials III: Nanoporous Gold and Phase Transformations

Time: Thursday 11:45–13:15 Location: H 0106

MM 52.1 Thu 11:45 H 0106

***In situ* mechanical testing of nanoporous gold: new insights into plasticity of nanostructures** — •Nadiia Mameka[1], Jürgen Markmann[1,2], and Jörg Weissmüller[1,2] — [1]Helmholtz-Zentrum Geesthacht — [2]Technische Universität Hamburg-Harburg

Surface plays a significant role in plasticity of nanoscale objects. This has been well documented by the size-dependent strength in recent studies on nanowires. Our research aims to contribute towards identifying the underlying processes for the observation by employing nanoporous gold (np-Au), as a material with large specific surface area in a network of nanowires or nanoligaments. The millimeter-seized np-Au samples were tested *in situ* in compression under potentiostatic control in aqueous electrolytes. The amount of the surface area was tuned by structural coarsening, while the state of the surface was controlled by application of an electrical potential E.

The electrode polarization of the Au-electrolyte interface results in an effective strengthening of np-Au by negative charging and specific adsorption at the surface. The overall flow stress σ_F as well as its potential-induced changes $\Delta\sigma_F/\Delta E$ scale with the ligament size. Remarkably, when normalized by the actual stress, the flow stress-potential coupling parameter $\Delta\sigma_F/\Delta E$ exhibits no size-dependence. This finding implies an important link between phenomena responsible for strengthening by electric potentials and strengthening by structural size. In this respect possible relevant mechanisms that control the plastic deformation will be discussed.

MM 52.2 Thu 12:00 H 0106

Investigation of the Deformation Behavior of Nanoporous Metals Using Digital Image Correlation — •Lukas Lührs[1], Jürgen Markmann[1,2], and Jörg Weissmüller[1,2] — [1]Institut für Werkstoffphysik und -technologie, Technische Universität Hamburg-Harburg — [2]Institut für Werkstoffforschung, Werkstoffmechanik, Helmholtz-Zentrum Geesthacht

Nanoporous metals have an extremely high specific surface area. This makes them of interest for studies of small-scale deformation, since the mechanical behavior can be manipulated through number and properties of the surfaces. A fundamental issue in elastic as well as plastic deformation of nanoporous metals is the transverse coupling, in other words, the link between longitudinal and transverse strain under uniaxial loading conditions. Millimeter sized nanoporous gold samples with different ligament size were prepared via dealloying and tested mechanically under single and cyclic compression up to strains of 50%. By using a digital image correlation set-up, 2-dimensionally resolved strain measurements of the sample surface could be obtained, enabled by full field displacement calculations upon loading. Among other material properties, the development of the elastic and plastic Poisson's ratio during the deformation process was determined. In each instance the lateral deformation is small. Yet, the transverse coupling does not vanish; this is contrary to some previously published claims. Furthermore, a significant dependence of the Poisson's ratio on the ligament size as well as the macroscopic strain was observed.

MM 52.3 Thu 12:15 H 0106

Investigation of the coarsening behaviour of nanoporous gold based on representative volumes — Kaixiong Hu[1], •Markus Ziehmer[1], Ke Wang[2], and Erica Lilleodden[1] — [1]Helmholtz-Zentrum Geesthacht, Institute of Materials Research, Materials Mechanics, Geesthacht, Germany — [2]Hamburg University of Technology, Institute of Materials Physics and Technology, Hamburg, Germany

Advances in 3D analyses by electron microscopy enable the detailed investigation of material systems exhibiting complex microstructures, such as nanoporous gold (npg). This in turn allows access to critical structural parameters needed to advance our understanding of material behaviour. In particular, the coarsening of the 3D bicontinuous pore-ligament network of npg is one problem, where 3D analysis helps to explore the applicability of scaling laws in mechanical behaviour, which implicitly assume structural self-similarity across varying length-scales. However, reliable answers require a careful identification of representative volumes, which mimic the characteristics of the global microstructure. We present an investigation on thermally induced coarsening of npg based on focused ion beam tomography. The presentation highlights the importance of properly identifying representative volumes for this type of material system. Results on crucial microstructure parameters like ligament size, surface curvature and network connectivity are shown, which seem to support the view of structural self-similar evolution of npg.

MM 52.4 Thu 12:30 H 0106

Influence of elastic stresses during the formation of hollow nanoparticles — •Manuel Roussel and Guido Schmitz — Lehrstuhl für Materialphysik, Universität Stuttgart, Heisenbergstr. 3, 70569 Stuttgart, Germany

The formation of hollow particles has been extensively studied during the past few years, and this enthusiasm assuredly comes from the fact that nanometric containers may have several applications in various fields (drug delivery, catalysis, composite materials). A multitude of various hollow architectures have been created, using various methods, as reported in hundreds of publications. However, numerous fundamental questions have not been clarified yet.

This project aims at investigating one of these questions. What mechanisms are involved during the creation of a hollow particle at the atomic scale? More precisely, we try to understand the link between solid state diffusion, non-equilibrium vacancies and diffusion-induced stresses during the formation of a Kirkendall void in core-shell nanostructures.

While finite element simulations allow us to apprehend the problem from a theoretical point of view, we also have a powerful characterization tool at our disposal: the Tomographic Atom Probe (TAP). Here, emphasis will be placed on showing how diffusion and phase transformation can be controlled using stress and geometry in a nanostructure. For instance, we will show how switching from a nanosphere to a nanowire configuration can drastically change diffusion kinetics at the atomic scale.

MM 52.5 Thu 12:45 H 0106

Molecular-dynamics simulation of martensite-austenite transition in nickel-titanium nanoparticles — •Christian Kexel[1], Stefan Schramm[1,2], and Andrey Solov'yov[1,3] — [1]Department of Physics, Goethe University, 60438 Frankfurt, Germany — [2]Frankfurt Institute for Advanced Studies, Goethe University, 60438 Frankfurt, Germany — [3]MBN Research Center, 60438 Frankfurt, Germany

Shape-memory alloys can after initial deformation reconstruct their pristine structure upon heating. The underlying phenomenon is the structural solid-solid transformation from low-temperature lower-symmetry martensite to high-temperature higher-symmetry austenite. The near-equiatomic NiTi possesses an eminent importance for biomedical applications whereas the nanostructured equivalent can exhibit yet enhanced thermomechanical properties. However, no plausible microscopic theory of the shape-memory effect in NiTi exists, especially for the nanoscale systems. In this work, the thermally-induced martensite-austenite transition in free nanocrystals with 8472 to 39349 atoms is investigated by means of classical molecular-dynamics simulations. Thereby a recently published study is complemented. Interatomic interactions are modeled by a semi-empirical many-body potential based on tight-binding second-moment approximation. The structural transition, revealing features of a first-order transformation, is successfully demonstrated and contrasted with melting, a quantum harmonic model and experimental findings. Moreover, a nucleation-growth process is observed as well as the irreversibility of the transition.

MM 52.6 Thu 13:00 H 0106

MORPHOLOGY AND PHASE TRANSFORMATION OF INDIUM NANOPARTICLES EMBEDDED IN AN ALUMINUM MATRIX — •Mostafa Mohamed, Martin Peterlecher, and Gerhard Wilde — Institute of Materials Physics, Münster, Germany

The melting , undercooling, and superheating of In- nanoparticles embedded in an Al matrix have been studied as a function of particle size by differential scanning calorimetry (DSC) and transmission electron microscopy (TEM). Different densities of nanometer-sized In particles that were uniformly embedded in an Al-matrix have been synthesized by rapid melt quenching. After systematic thermal treatments, a portion of the In-particles showed an increase of the melting temperature compared to the bulk behavior. Analyses of DSC measurements and

TEM images were carried out to analyze the impact of the interfaces between nanoparticles and matrix as well as of pressure effects on the melting/freezing phase transformation. The properties of embedded and grain boundary particles are also discussed.