MM 40: Nanomaterials II: Mechanical Properties

Time: Wednesday 15:45–18:00 Location: H 0107

MM 40.1 Wed 15:45 H 0107

Mechanical properties of Cu-Zr multi-composition nanoglasses — •Omar Adjaoud and Karsten Albe — Technische Universität Darmstadt, Fachbereich Material- und Geowissenschaften, Fachgebiet Materialmodellierung, Jovanka-Bontschits-Str. 2, D-64287 Darmstadt, Germany

Nanoglasses can be produced by consolidation of glassy nanoparticles which are prepared by inert-gas condensation. The microstructure of nanoglasses consists of glassy regions separated by glass-glass interfaces. These interfaces influence many properties of nanoglasses such as mechanical properties. It is know that the bulk metallic glasses with different composition response differently to the external load. In this work, we perform molecular dynamics simulations to address the question whether the composition of glassy nanoparticles could affect the mechanical properties of nanoglasses. we prepare multi-composition nanoglasses by compaction of several Cu-Zr glassy nanoparticles which have different composition. We discuss the behavior of the multi-composition nanoglasses during the mechanical tests in terms of local atomic strain and the atomic structure of the glassy nanoparticles forming the nanoglass.

MM 40.2 Wed 16:00 H 0107

Mechanical properties of Cu-Zr multi-composition nanoglasses — •Omar Adjaoud and Karsten Albe — Technische Universität Darmstadt, Fachbereich Material- und Geowissenschaften, Fachgebiet Materialmodellierung, Jovanka-Bontschits-Str. 2, D-64287 Darmstadt, Germany

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MM 40.3 Wed 16:15 H 0107

Aspects of universal yield behavior of bulk metallic glasses unraveled in nanocrystalline Pd-Au alloys — •Andreas Leibner, Christian Braun, Jonas Heppe, Manuel Grewer, and Rainer Birringer — Universität des Saarlandes, FR7.2 Experimentalphysik, Campus D2 2, 66123 Saarbrücken

We present experimental evidence that plastic yielding of nanocrystalline (NC) metals at the low end of the nanoscale is reminiscent of universal yield behavior of metallic glasses. NC Pd-Au samples with a grain size of $D \lesssim 10\,\mathrm{nm}$ and isotropic microstructure were deformed under different conditions: From strain-rate dependent deformation studies on shear-compression-specimens, we find that the energy barrier height of NC Pd_{90}-Au_{10} exhibits universal scaling behavior $\Delta G \propto \Delta\tau^{3/2}$ [1], where $\Delta\tau$ is a residual load, giving rise to a generalization of the Johnson-Samwer $T^{2/3}$ scaling law [2] of yielding in metallic glasses. Additionally, we use microhardness as measure for the shear yield stress of Pd-Au samples with different Au-concentrations (and concomitantly different elastic moduli). As a result, the NC alloys exhibit the linear correlation $\tau_y/G = 0.00267 \pm 0.002$ discovered for over 30 bulk metallic glasses [2]. Since shear transformations are considered to be the generic flow defect in metallic glasses, it seems reasonable to suppose that shear softening of grain boundaries provokes the occurrence of shear transformations.

[1] M. Grewer and R. Birringer, PRB **89**, 184108 (2014)
[2] W.L. Johnson and K. Samwer, PRL **95**, 195501 (2005)

MM 40.4 Wed 16:30 H 0107

An analysis of thermal activation parameters in nanocrystalline metals — •Anja Steinbach, Manuel Grewer, and Rainer Birringer — Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus D2.2, 66123 Saarbrücken

We studied the plasticity of thermally equilibrated and non-equilibrated nanocrystalline (NC) $Pd_{90}Au_{10}$ samples with grain sizes below 10 nm by using the miniaturized shear compression specimen (m-SCS) [1]. We performed strain-rate and temperature-dependent mechanical tests under dominant shear and superimposed compression up to large plastic strains to deduce the shear activation volume Δv, strain-rate sensitivity m, as well as the Gibbs free energy of activation ΔG. These thermal activation parameters are most informative for probing the mechanisms of thermally activated plasticity [2].

[1] M. Ames, J. Markmann, R. Birringer, Mater. Sci. Eng. A 528, 526 (2010)
[2] M. Grewer, and R. Birringer, Phys. Rev. B 89, 184108 (2014)

15 min. break

MM 40.5 Wed 17:00 H 0107

X-ray nanodiffraction meets materials science — •Christina Krywka[1], Stephan Roth[2], and Müller Martin[1] — [1]Helmholtz-Zentrum Geesthacht, Max-Planck-Straße 1, Geesthacht D-21502 — [2]DESY, Notkestraße 85, Hamburg D-22607

The Nanofocus Endstation of beamline P03 (PETRA III, Hamburg) is operated jointly by Helmholtz Zentrum Geesthacht and the University of Kiel, and is one of the very few synchrotron endstations providing the experimental conditions for scanning X-ray nanodiffraction. This technique, in turn, is an excellent tool for materials science. It readily serves structural information with sub-micrometer spatial resolution from crystalline and semi-crystalline materials (metals, biomaterials, synthetic compounds) for the retrieval of e.g. grain orientation, residual stress profiles, crystal structure or texture. Because of the long focal distance focusing, the wide energy range of the P03 beamline and a hexapod based positioning system, high resolution nanodiffraction experiments can be performed on strongly absorbing metallic samples and in extended sample environments, using a beam with a size of only 350 nm * 250 nm, generated using a long focal distance focusing system.

The strong focus on materials science at P03 is demonstrated by the wide range of experiments already performed with in situ sample environments: pressure, indentation force, tensile stress, fluid shear, magnetic fields - all of these parameters were successfully modified in situ and combined with the high spatial resolution provided by nanofocused beam.

MM 40.6 Wed 17:15 H 0107

Tunable magnetic anisotropy in elongated Ni nanoparticles embedded in SiO2 matrix by swift heavy ions irradiation — •Debalaya Sarker, Santanu Ghosh, and Pankaj Srivastava — Department of Physics, Indian Institute of Technology Delhi

The discovery of nanoparticle elongation inside insulator matrix by swift heavy ion (SHI) irradiation and its association to thermal spike model has led to interest in different physical properties of such systems. The ease of switching the easy axis of magnetization by elongating embedded ferromagnetic Ni nanoparticles in insulator matrix by SHI bombardment in the direction of incident beam, has motivated the present study. Ni foils glued on SiO2 target were co-sputtered. Irradiation with 100 MeV Au+7 SHI was carried out at different fluences. GISAXS analysis confirms elongation of NPs along beam direction but along with an overall volume reduction. In-plane and out-plane M-H measurements at 5 K show that gradual increase in saturation magnetization and coercivity till 5.0*1013 ions/cm2 fluence. XANES and valence band XPS show narrowest 3d electron-band for the same, resulting in maximum spin polarization. We conclude that at further higher fluences dissolution of NPs have caused overall volume reduction and hence results in reduction of shape anisotropy originated perpendicular magnetization. Thus the intermediated fluence irradiated film, having the maximum out of plane magnetization, can find its promising applications in future perpendicular magnetic storage devices capable of thrice storage capacity in comparison to normal linear storage media.

MM 40.7 Wed 17:30 H 0107

Synthesis and Properties of Solids Composed of Organic-

Linked Nanoparticles — •Axel Dreyer[1], Artur Feld[2], Ezgi D. Yilmaz[1], Wolfgang Heckel[1], Stefan Müller[1], Horst Weller[2], and Gerold A. Schneider[1] — [1]Hamburg University of Technology, Institute Advanced Ceramics, Hamburg, Germany — [2]Hamburg University, Institute of Physical Chemistry, Hamburg, Germany

Natural hard tissues like nacre or enamel are characterized by outstanding mechanical properties in relation to their rather weak mechanical constituents. They key of their mechanical behavior is the combination of hard inorganic and soft organic constituents in a hierarchical structure, which starts on the nanoscale. Our approach is an attempt to synthesize the first hierarchical level by the self-organization of organic-coated nanoparticles into close-packed superstructures. The organic molecules play a prominent role by providing cohesion in the material via strong coordinated binding of functional groups to the inorganic particles as well as weak van der Waals binding between adjacent molecules. We present the successful manufacturing of extensive nano-particle superstructures by a sequence of sedimentation, drying, heating, and pressing of monodispersed spherical iron oxide particles. In a subsequent step we will increase the interparticle binding energy by controlled chemical crosslinking within the organic shell of the solid particle superstructures. The mechanical properties of these nano-composites like hardness, elastic modulus, and strength will be discussed and related to the binding energy in the interparticle space.

MM 40.8 Wed 17:45 H 0107

Bilayer Gold Nanostructures for Optical Activity in the Visible Range — •Katja Höflich[1,2], Gaudhaman Jeevanandam[2], Julia Schneider[2], Caspar Haverkamp[1,2], and Silke Christiansen[1,2] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin — [2]Max-Planck-Institut für die Physik des Lichts, Günther-Scharowsky-Str. 1, 91058 Erlangen

Tailored manipulating of light onto the nanoscale is key for any nano-optical application. Especially, turning the polarization vector of mostly circularly polarized light by so-called optically active nanostructures created huge interest in the in the fast-growing field of plasmonics and metamaterials. Here we present optical activity in the visible range for chiral nanostructures combining positive with the corresponding negative L-shapes in a bilayer system with strong near-field coupling through a silicon dioxide membrane. Using electromagnetic modeling (finite difference time domain) the structures were optimized with respect to small ellipticity (defining the deformations of the incident circular polarization state) while guaranteeing large optical activity. The fabrication is based on focused ion beam milling of single-crystalline gold flakes and dedicated nano-manipulation, spectroscopic characterization was carried out in a fiber-coupled optical microscope equipped with a Horiba spectrometer.