MM 37: Mechanical Properties II

Time: Wednesday 14:45–16:15 Location: H16

MM 37.1 Wed 14:45 H16

An alternative way to determine Young's modulus of thin films — •Matthias Herrmann and Frank Richter — Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany

An extension for the original approach of Pharr's and Bolshakov's *effective indenter* concept given by Schwarzer (J. Phys. D: Appl. Phys. 37 (2004) p.2761) allows one to apply linear elastic contact solutions for layered half spaces to actual elastic-plastic indents and, hence, might be taken into account as an alternative way to analyze the elastic response of thin films. In this contribution, it is discussed to what extent the *effective indenter* concept can be used to determine Young's modulus of a thin film. Therefore, a thermally grown SiO_2 film and *a*-C:H films deposited by PECVD were exemplarily used. For each sample, elastic-plastic load-depth curves (Berkovich) for a series of varying maximum loads were analyzed in order to realize the *effective indenter* approach for data of varying contact depth to film thickness ratio. The modulus values obtained in this way were in reasonable agreement to those obtained by elastic spherical indentations if the contact depth to film thickness ratio was sufficiently low. Physical mechanisms are discussed as reasons for the deviation obtained at higher contact depths.

MM 37.2 Wed 15:00 H16

Creep measurements on ultra-fine grained copper after high-pressure torsion straining — •Jörn Leuthold[1], M. Wegner[1], S. Divinski[1], K. A. Padmanabhan[1], D. Setman[2], M. Zehetbauer[2], and G. Wilde[1] — [1]Institut für Materialphysik, Universität Münster, Germany — [2]Fakultät für Physik, Universität Wien, Austria

Ultrafine grained materials, especially such materials that have been processed by severe plastic deformation under a high hydrostatic pressure, present unique properties such as an increase in yield strength and simultaneously a considerable uniform tensile elongation before failure. The small grain size and the presence of defects with high specific excess energy densities lead to modifications of the basic mechanisms that can accommodate externally applied mechanical stresses. Grain boundary controlled mechanisms, such as grain boundary emitted dislocations and partial dislocations, twinning, grain boundary diffusion and sliding can be more important or even dominant. To study the deformation behavior, several copper samples were prepared by High Pressure Torsion, a technique to induce high shear stresses on a specimen to produce fine grained, bulk material. The characterization of the microstructure in terms of grain size distributions, misorientation of grain boundaries and texture was done by electron backscatter diffraction. A miniaturized device for creep measurements was constructed to perform tensile creep tests under uniaxial conditions at temperatures from 273K to 348K. The measurement of the activation energy for the rate controlling creep mechanism is set into context with grain boundary diffusion experiments.

MM 37.3 Wed 15:15 H16

Creep with Single Dislocation Resolution — •Philip Egberts[1,2] and Roland Bennewitz[1,2] — [1]INM-Leibniz Institut für Neue Materialien, Campus D2 2, 66111 Saarbrücken, Germany — [2]Department of Physics, McGill University, 3600 rue University, Montreal, Quebec, H3A 2T8, Canada

Creep in materials is a result of four contributing factors: dislocation glide, dislocation creep, diffusion processes, and grain boundary climbing. Atomic Force Microscopy (AFM) is able to deform materials and detect dislocation nucleation on the atomic scale. The application of AFM to the study of creep highlights one single factor, dislocation glide. The sharp tip of an AFM probe, having a tip radius of <10 nm, was used to both image and indent KBr(100) surfaces in ultrahigh vacuum. The small tip radius and high resolution capabilities of AFM allowed for the probing of a dislocation and defect free volume while allowing for the application of stresses in the GPa range with the application of nanoNewton forces. Rapid measurements of the cantilever deflection during creep studies allow for discrete atomic pop-in events to be observed as a function of holding time. Dislocation generation for up to four minutes after reaching the maximum load is observed.

MM 37.4 Wed 15:30 H16

In-situ tensile testing of Au nanowires — •Burkhard Roos[1], Gunther Richter[2], Andreas Sedlmayr[3], Reiner Mönig[3], and Cynthia A. Volkert[1] — [1]Institut für Materialphysik, Universität Göttingen — [2]Max-Planck-Institut für Metallforschung, Stuttgart — [3]Institut für Materialforschung, Karlsruhe Institute of Technology

The increase in strength with decreasing size is a ubiquitous phenomenon in metals. Particularly for free standing samples with dimensions below 100 nm, where dislocation storage is hard to envision, a convincing explanation for the size-dependent strength is missing. The goal of this study is to directly observe dislocations in small volumes, using in-situ TEM during deformation. Single crystal Au nanowires with diameters between 40 and 70 nm have been used. During deformation, crystallographic planar defects appear in the wires, remain fixed as the wire is further deformed, and then may eventually disappear. The defects nucleate homogeneously along the wire length and appear and disappear between camera frames, in less than 50 ms. In-situ tensile testing of the wires in an SEM reveals stresses at failure in the range of 0.4 and 1.5 GPa for wires with diameters between 80 nm and 400 nm. The measured stress-strain response exhibits extensive plastic flow. Post-deformation TEM studies indicate that the defects are nanotwins, which may be formed by the nucleation and motion of partial dislocations. Possible explanations for the dependence of partial dislocation nucleation on wire diameter and stress will be discussed.

MM 37.5 Wed 15:45 H16

Recrystallisation of single-phase Copper alloys investigated by resistance measurements — •Alexander Kauffmann[1,2], Jens Freudenberger[1], Hansjörg Klauss[1], Tom Marr[1,2], Konstantin Nenkov[1], Vadlamani Subramanya Sarma[3], Jürgen Eckert[1,2], and Ludwig Schultz[1,2] — [1]IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany — [2]TU Dresden, Institute of Materials Science, 01062 Dresden, Germany — [3]Dept. Metallurgical and Materials Engineering, IIT Madras, Chennai 600036, India

Copper based solid solutions with different contents of solute elements (Zn, Al, Ga, Sn, Ge) were deformed at room-temperature and at liquid Nitrogen temperature. The recrystallisation behaviour of these alloys has been investigated by means of dynamic and isothermal measurements of the resistivity (ρ). Variations of ($d\rho/dT$) from ($\rho_0\,\alpha$) are interpreted in terms of changes in defect densities by recovery and recrystallisation. Deviations from a linear temperature depedence of the resistivity increase with increasing solute concentration and depend on the stacking fault energy (γ). We observe a ($1/\gamma^2$)-dependency of the deviations which are also influenced by the deformation temperature. During deformation, γ controls the possibility to store deformation energy in the form of dislocations and deformation twins. In combination with the general trend of alloying elements to shift recrystallisation to higher temperatures, the recrystallisation behaviour of single-phase copper alloys has been described qualitatively. The observed stored dislocation and twin densities interfere with solution hardening to the macroscopic strength after deformation.

MM 37.6 Wed 16:00 H16

Simulation of the in-plane plastic anisotropy of ultrafine grained aluminum sheets produced by accumulative roll bonding — •Benoit Beausir[1], Scharnweber Juliane[1], Jaschinski Jörn[2], Brokmeier Heinz-Günter[3], Oertel Carl-Georg[1], and Skrotzki Werner[1] — [1]Institut für Strukturphysik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Institut für Leichtbau und Kunststofftechnik, Technische Universität Dresden, D-01062 Dresden, Germany — [3]GKSS Forschungszentrum, Max-Planck-Straße, D-21494 Geesthacht, Germany

Besides grain refinement accumulative roll bonding (ARB) leads to the formation of a texture composed of rolling and shear components. The shear components produced by friction between the rolls and the sheet are found in the surface layers. During subsequent ARB cycles, due to the bonding process the surface shear texture extends into the bulk of the sheet. Eight cycles of ARB were performed on two aluminum alloys, AA1050 and AA6016. The plastic anisotropy was investigated by tensile deformation via Lankford parameter. The global texture of the sheets was measured by neutron diffraction and used as input of the viscoplastic self-consistent model to simulate the in-plane plastic anisotropy. Simulation results are compared with those from experiment and discussed with regard to texture, strain rate sensitivity, grain shape and slip system activity.