MM 29: Mechanical Properties I

Time: Wednesday 14:00–15:15 Location: H 0111

MM 29.1 Wed 14:00 H 0111

Molecular Dynamics Simulations of Grain Boundary Plasticity — •Yvonne Ritter, Alexander Stukowski, and Karsten Albe — Institut f. Materialwissenschaft, TU Darmstadt, Petersenstr. 23, D-64287 Darmstadt

Dislocation nucleation at grain boundaries (GB) and as well as grain boundary sliding are relevant mechanisms governing the deformation behavior of nanocrystalline metals. By means of molecular dynamics simulations we examine well defined bicrystal geometries under different loads. The simulations are performed for copper and aluminum in order to investigate the influence of various stacking fault (SF) energies. For a Σ 7 (111) twist boundary GB sliding occurs by a collective movement of all atoms in the boundary plane, but no dislocation activity can be detected. A Σ 33 (225) tilt boundary with a dissociated structure dos not deform by GB sliding but reacts by the growth of pre-existing intrinsic stacking fault facets when exposed to a shear deformation. Under tensile deformation partial dislocations nucleate from both GBs. The nucleation mechanism is thermally activated in both cases. In the case of the Σ 7 GB the dislocations are statistically emitted from tetrahedral nucleation sites. The partial dislocations, that are emitted from the Σ 33 GB, emerge at well defined positions determined by the GB structure.

MM 29.2 Wed 14:15 H 0111

Micropillars compression test — •Nousha Kheradmand, Afrooz Barnoush, and Horst Vehoff — Saarland University Bldg. D22 P.O. Box 151150, Postcode D-66041, Saarbruecken, Germany

In order to investigate the size effect compression test of single crystal micropillars was performed. Micropillars with different crystallographic orientations were fabricated by focused ion beam and the compression test was performed in a nanoindenter utilizing a flat punch tip. As a new approach in order to observe the micropillars in their intermediate deformation conditions, the compression test was performed stepwise. Between each step the micropillars were imaged in a scanning electron microscope. The engineering stress-strain curves of the micropillars show a clear size effect on mechanical properties of the samples. The small samples show a linear elastic-perfectly plastic deformation followed by incremental strain bursts, while the larger samples show a continuously flow curve. This difference could be described by a so called source truncation strengthening model which occurs in samples with small diameter. According to this model a Frank-Read source line during the growth reaches the free surface before it is able to be multiplicated. This leaves two single-arm dislocations which are pinned from one end inside the sample and from the other end on the free surface. These dislocations introduce to the samples new yield stresses.

MM 29.3 Wed 14:30 H 0111

Determination of intrinsic stresses in thin films by nanoindentation — •Olena Chukhrai[1], Andre Clausner[1], Norbert Schwarzer[2], and Frank Richter[1] — [1]Chemnitz University of Technology, Institute of Physics, Chemnitz, Germany — [2]SIO - Saxonian Institute of Surface Mechanics, Eilenburg, Germany

Intrinsic stresses often occur in thin films as a result of the complex formation of the thin film structure. Therefore, simultaneous determination of intrinsic stress and yield strength are necessary. It was shown [1], that intrinsic stresses can be derived from nanoindentation data by combination of "pure normal"and mixed (normal and tangential) loading, in particular, when the concept of the "effectively shaped indenter"is used. A device for creation of biaxial stress in the samples which can be used together with our nanoindentation setup (UNAT, Asmec GmbH) was constructed, tested and utilized for the investigation of a highly elastic Ni/Ti alloy. We found that for the NiTinol hardness changed by more than 70% when the stress was varied between 0 and 0.9 GPa. Using our theoretical concept [1], the intentionally introduced biaxial stress could be taken into account and the yield strength could be determined. The next step was to apply for the samples with known biaxial stress a combination of "pure normal"and mixed loading with pointed indenter and to determine the intrinsic stress and the yield stress using our theory. The feasibility of the concept of simultaneous determination of intrinsic stresses and yield strength by nanoindentation was shown and it can now be used.

[1] Schwarzer N.: http://archiv.tu-chemnitz.de/pub/2006/0018/index.html

MM 29.4 Wed 14:45 H 0111

In situ tensile testing of nanocrystalline Pd and Pd-Ag alloys — •Kejing Yang[1], Julia Ivanisenko[2], Jürgen Markmann[3], and Hans-Jörg Fecht[1,2] — [1]Institute of Micro and Nanomaterials, University of Ulm, D-89081 Ulm, Germany — [2]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [3]Universität des Saarlandes, FR7.3 Technische Physik, Saarbrücken, Germany

Arising from a low strain hardening ability, the limited uniform elongation of nanocrystalline materials (NC) hinders the further improvement of their mechanical properties. In this study we suggest a way to enhance strain hardening by purposefully alloying Pd to reduce its stacking fault energy (SFE). Nanocrystalline Pd and Pd-Ag alloys were prepared by high-pressure torsion. Tensile testing was carried out in situ in a high-resolution SEM to investigate the mesoscopic deformation process at a strain rate of 10-3 s-1. The NC alloys demonstrated very high values of strength and ductility. The true stress-true strain curves exhibit a larger strain hardening effect and larger uniform deformation in Pd-Ag alloys than in pure Pd. We relate this enhanced behavior to a decreased SFE in the alloys: the lower the SFE, the more difficult is the cross slip and climb of split dislocations, which leads to greater dislocation storage and, ultimately, to increased strain hardening. The dimpled structure of fracture surfaces in the alloys will also be discussed in relationship to these findings.

MM 29.5 Wed 15:00 H 0111

New approach to design the strain hardening ability in nanostructured materials. (exchanged with MM 30.1) — •Lilia Kurmanaeva[1], Yulia Ivanisenko[1], Jürgen Markmann[2], Jörg Weissmüller[1,2], Ruslan Z. Valiev[3], and Hans-Jörg Fecht[4] — [1]Institute für Nanotechnology, Forschungszentrum Karlsruhe, Karlsruhe, Germany — [2]Universität des Saarlandes, Saarbrücken, Germany — [3]Institute of Phisycs of Advanced Materials, Ufa, Russia — [4]Institute of Micro and Nanomaterials, University of Ulm, Ulm, Germany

The recent past has seen an increasing interest in studies of mechanical properties of nanostructured materials(NSM), since new methods of continuous processing of bulk NSM using severe plastic deformation were developed. NSM demonstrate superior hardness and strength, but often a limited ductility due to poor strain hardening(SH) ability. In present paper we suggest a simple method to increase the SH ability of NSM by decreasing the stacking fault energy(SFE). The microstructure and mechanical properties of nanocrystalline Pd and Pd-x%Ag(x=5,10,20,40) alloys were investigated. Additions of Ag strongly decrease the SFE of Pd. The initially coarse grained samples were processed by high pressure torsion, which resulted in formation of homogeneous ultrafine-grained structure. The increase of Ag contents led to the decrease of the resulted grain size. Consequently, the samples with larger Ag contents demonstrated the higher values of strength properties. The uniform elongation had also increased, and tensile curves exhibited larger SH. Thus we have obtained a combination of high strength and good ductility in nanostructured Pd-Ag alloy.