MM 48: Nanostructured Materials IV

Time: Friday 10:15–12:00 Location: IFW B

MM 48.1 Fri 10:15 IFW B

'Non-Equilibrium' Grain Boundaries in Severely Deformed Materials: Myths vs. Reality — •Sergiy Divinski and Gerhard Wilde — Institut für Materialphysik, Universität Münster, Germany

Recent results on radiotracer diffusion in nanostructured and ultrafine grained materials produced by severe plastic deformation are reviewed. The data reveal a strong hierarchy of short-circuit diffusion paths in these materials – the ultra-fast diffusion paths (the top level of the hierarchy) turn out to be embedded in a network of relatively slower diffusion paths (the bottom level). The 'slow' paths are shown to represent the relaxed high-angle grain boundaries, which are the fastest short-circuit diffusion paths in annealed coarse-grained counterparts. The nature and origin of the ultra fast paths is examined and discussed in relation to the so-called "non-equilibrium"grain boundaries in severely deformed materials.

MM 48.2 Fri 10:30 IFW B

Ultra-fast diffusion pathways in severely deformed Nickel — •Gerrit Reglitz[1], Yuri Estrin[2], Sergiy Divinski[1], and Gerhard Wilde[1] — [1]Institut für Materialphysik, Universität Münster, Germany — [2]Monash University, Claytoon, Victoria, Australia

During recent years, so-called non-equilibrium grain boundaries with high densities of extrinsic (excess) dislocations have been suggested to exist in severely deformed materials. These defects that are supposedly characterized by a large excess energy density are brought forward in explanations of the unusual properties and property combinations of such materials. However, such grain boundaries should also present highly unusual diffusion properties, i.e. the grain boundary diffusivity of non-equilibrium grain boundaries should be much higher than the diffusivity of conventional high-angle grain boundaries.

In order to analyze the possible existence of these non-equilibrium defects, grain boundary diffusion studies on Ni after severe plastic deformation by Equal Channel Angular Pressing has been carried out by applying the ^{63}Ni radioisotope in combination with the parallel sectioning technique. First results indicate the existence of ultra fast short-circuit diffusion parts with duffusivities of several orders of magnitude higher than the diffusivities of relaxed high-angle grain boundaries. These results together with recent results obtained on pure Cu and Cu-rich alloys deformed also by ECAP are discussed with respect of the origin of these ultra-fast diffusion pathways and their possible relation to non-equilibrium grain boundaries.

MM 48.3 Fri 10:45 IFW B

Annealing behaviour of equiatomic nanocrystalline NiTi alloy produced by high-pressure torsion — •Reeti Singh[1], Sergiy Divinsky[1], Ruslan Z. Valiev[2], and Gerhard Wilde[1] — [1]Institut für Materialphysik, Westfälische Wihelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149, Münster, Germany — [2]Institute of Physics of Advance Materials, Ufa State Aviation University,12 K. Marx Street, 450000 Ufa, Russian Federation

A nanocrystalline $Ni_{50}Ti_{50}$ alloy that had been severely deformed by high-pressure torsion (HPT) was investigated. Both amorphous and nanocrystalline phases were found to co-exist in the as-prepared state. Crystallization and structural changes during annealing were investigated by differential scanning calorimetry (DSC), X-ray diffraction analysis and transmission electron microscopy.

The DSC thermograms and X-ray analyses reveal stress relaxation and partial crystallization below 500 K while grain growth of the nanocrystals occurs predominantly after heating to temperatures above 523 K. The activation energy of grain growth was estimated to be 289 kJ/mole by applying a Kissinger analysis. Along with the amorphous phase crystallization, a continuous growth of pre-existing nanocrystals that are retained after HPT, is observed. The DSC signals observed during continuous heating experiments indicate an unusually large separation between the nucleation and the growth stages. This behavior, that also causes a large variation of the nanocrystal size after annealing at higher temperatures, is discussed with respect to the nanoscale microstructural heterogeneity after initial deformation.

MM 48.4 Fri 11:00 IFW B

Microstructure and texture evolution during high pressure torsion of a Cu-0.17wt%Zr alloy — •Anahita Khorashadizadeh, Myrjam Winning, and Dierk Raabe — Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf, Germany

Investigations of the microstructure of materials processed via severe plastic deformation methods such as high pressure torsion and their recrystallization behavior is of great interest as they are capable of producing ultra fine grained material with good mechanical properties. In this study Cu-0.17wt%Zr has been subjected to high pressure torsion (HPT) with a maximal pressure of 4.8 GPa at room temperature up to shear strains of γ=78. Annealing of the deformed samples was carried out subsequently and microstructure of both the deformed and annealed samples was investigated using a scanning electron microscope and microhardness measurements, in order to analyze the recrystallization behavior of the HPT samples. It will be shown that simple shear texture components represented by A-fiber {111}<uvw> and B-fiber {hkl}<110> were developed during the HPT deformation. After annealing, the ideal shear texture components still exist despite a change in texture intensity. The local orientations of deformed and annealed samples were analyzed using electron back scatter diffraction to obtain information about the recrystallization process.

MM 48.5 Fri 11:15 IFW B

Mechanical Properties of Nanocrystalline Palladium Prepared by Magnetron Sputtering — •Anna Castrup[1,2], Torsten Scherer[1], Yulia Ivanisenko[1], Horst Hahn[1,2], In-Suk Choi[1], and Oliver Kraft[1] — [1]Forschungszentrum Kalrsruhe, Germany — [2]Technical University of Darmstadt, Germany

Nanocrystalline metals and alloys with grain sizes well below 100 nm often demonstrate unique deformation behaviour and therefore attract a great interest in material science. The understanding of deformation mechanisms operating in nanocrystalline materials is important to predict their mechanical properties.

In the present study Pd films of 1 μm thickness were prepared using UHV rf magnetron sputtering on dog bone shaped Kapton substrates and on Si/SiO2 wafers. The films were sputtered using multilayer technology with an individual layer thickness of 10 nm. This resulted in grain sizes of about 20 nm.

Initial microstructure and texture were characterized using conventional XRD measurements and transmission electron microscopy (TEM) in both cross section- and plane view. The mechanical properties were investigated using tensile testing and nanoindentation at several strain rates. An increased hardness and strength as compared to coarse grained Pd was observed, as well as high strain rate sensitivity. The microstructure in the gauge section after tensile testing was again analyzed using TEM in order to reveal signatures of deformation mechanisms like dislocation motion or twinning.

MM 48.6 Fri 11:30 IFW B

Plasticity in Nanocrystalline Tungsten — •Jonathan Schäfer and Karsten Albe — Institut f. Materialwissenschaft, TU Darmstadt, Petersenstr. 23, D-64287 Darmstadt

Computational simulation methods such as the molecular dynamics method are very useful to gain more insights into the deformation mechanisms of nanocrystalline materials. Especially for the class of fcc metals a lot of simulations have been carried out in the past in order to investigate dislocation emission, grain boundary sliding, and other processes on the atomic level. For the class of bcc materials, however, a complete map of deformation mechanisms is still missing and supposed mechanisms like the formation of cracks at the grain boundaries have not been confirmed yet. Tungsten as a bcc model material is of particular interest because its melting point, which is higher than for any fcc material, might permit the observation of thermally activated processes during deformation at elevated temperatures. We present Molecular Dynamics simulations of nanocrystalline Tungsten model structures generated using the Voronoi method. Deformation experiments are carried out at different temperatures and various loading conditions. The role of the interatomic potential (Analytic bond order potential, Finnis-Sinclair potential) and the influence of the structure synthesis method on the mechanical behavior are assessed. Additionally, mechanisms like crack formation at grain boundaries are addressed.

MM 48.7 Fri 11:45 IFW B