MM 29: Topical Session Bulk Nanostrucured Materials VI - Mechanical Properties I

Time: Wednesday 10:15–11:45 Location: H 0107

Topical Talk MM 29.1 Wed 10:15 H 0107

Texture, microstructure and mechanical properties of ARB aluminium laminates — •Werner Skrotzki — Institut für Strukturphysik, Technische Universität Dresden, D-01062 Dresden, Germany

Aluminium sheets with layers of different purity (A: 99.999 and B: 99.5) produced by accumulative roll bonding (ARB) were studied for different numbers of ARB cycles. Both material layers show a contrasting dynamic recrystallization behaviour with A and B recrystallizing discontinuously and continuously, respectively. The layered structure is stable up to 6 cycles, for higher cycles slightly necking starts. Global textures were measured by neutron diffraction while local textures of the different layers were measured by X-ray as well as electron backscatter diffraction (EBSD). The microstructure is analyzed from EBSD mappings. The mechanism of texture and microstructure development will be discussed in detail through thickness and with the number of ARB cycles. The strength and Lankford parameter were measured by tensile testing. ARB increases the tensile strength significantly. The planar anisotropy decreases with the number of ARB cycles while the normal anisotropy reaches a plateau after 2 cycles. The results will be compared with simulations on the plastic anisotropy of laminated structures.

MM 29.2 Wed 10:45 H 0107

Mechanical properties of Ti- and TiAl3 reinforced ultrafine-grained aluminium — •Christian Werner Schmidt, Heinz Werner Höppel, and Mathias Göken — Institute I: General Materials Properties, Department Materials Science and Engineering, Friedrich-Alexander-Universität Erlangen-Nürnberg

In this work titanium particles (d ~ 2 to 4 micron) are introduced in a highly controlled manner by airgun spraying from aqueous suspension into aluminium AA1050A by accumulative roll bonding (ARB). A layered ultrafine-grained (UFG) material with extraordinary mechanical properties, further reinforced with metallic particles is produced. By diffusional annealing, the metallic titanium particles are converted to the very hard intermetallic phase TiAl3, where the UFG matrix is recrystallized and softened. In order to re-establish the UFG structure three subsequent ARB cycles are executed. By tensile testing of the different states, strengthening effects by the grain size, particle volume fraction, and material are distinguished. Therewith the basic understanding of the mechanism of reinforcement by particles in ultrafine-grained metals is enhanced. The TiAl3 reinforced ultrafine-grained aluminium sheets are very promising due to enhanced strength as well as clearly improved thermal stability of the UFG structure caused by particle reinforcement.

MM 29.3 Wed 11:00 H 0107

Grain boundary mediated plasticity in nanocrystalline metals and their alloys: On the interplay of mesoscopic sliding, coupled motion and segregating solutes — •Jonathan Schäfer and Karsten Albe — TU Darmstadt, Darmstadt, Germany

As the grain size is decreased into the lower nanometer (nm) range, the contribution of grain boundary (GB) mediated processes to low temperature plastic deformation increases. Hahn and Padmanabhan postulated that in nanocrystalline materials neighboring GBs can align themselves, allowing for GB sliding on a mesoscopic scale. Depending on the misorientation of the boundary, it was shown by Cahn et al., that GB motion can couple to shear deformation and move perpendicular to the shearing direction (out of the shear plane). This leads to a competition between mesoscopic GB sliding and coupled GB motion. For studying this competition and the effect of segregating solutes, we utilize molecular dynamics simulations, where nc Cu and CuNb serve as model systems. By testing a suitable microstructure under tensile and compressive load, we find that depending on the type of the GB, coupled motion out of the sliding plane is observed. This inevitably hinders any potential alignment and therefore prohibits mesoscopic GB sliding. For the case of samples with segregating solutes in the GB we show that it is a delicate function of composition, whether a given GB is pinned in place allowing for mesoscopic sliding or can leave the slide plane by coupled GB motion.

MM 29.4 Wed 11:15 H 0107

Thermal stability and strain-rate sensitivity of nanocrystalline Ni and a Ni/Al2O3 nanocomposite — •Michaela Prell[1], Karsten Durst[1], Harald Natter[2], Anne Jung[2], and Mathias Goeken[1] — [1]Institute of General Materials Properties, Department of Materials Science and Engineering, University of Erlangen-Nürnberg — [2]Physical Chemistry, Saarland University, Saarbruecken, Germany

The thermal stability and strain-rate sensitivity of a nickel-alumina nanocomposite and nanocrystalline Ni with different amount of grain refiner has been studied using compression tests up to 300°C and microstructural investigations with scanning and transmission electron microscopy. It is found that during deposition, the Al2O3 particles form clusters, which are evenly distributed in the nc-Ni microstructure. The initial hardness and flow stress of the nc-Ni/Al2O3 is smaller compared to nc-Ni, but with heat treatment or testing at higher temperatures, nc-Ni/Al2O3 shows a higher strength and higher strain rate sensitivity. For nc-Ni, even at an annealing temperature of 250°C strong grain coarsening has been found, where initially large grains are embedded in a nanocrystalline matrix. For longer annealing times, a stable ultrafine grain size of ~1 micron was observed. During compression test at 250°C however, homogenuous grain coarsening is observed. The stability of the microstructure against coarsening due to the Al2O3 particles is discussed as one of the main reasons for the enhanced properties of the nanocomposite.

MM 29.5 Wed 11:30 H 0107

Effects of alloying and temperature on the mechanical behavior of nanocrystalline Palladium alloys — •Ruth Schwaiger, Thomas Neithardt, and Oliver Kraft — Karlsruhe Institute of Technology (KIT), Institute for Applied Materials (IAM)

Over the past decade significant advances in understanding the deformation mechanisms in fine-grained metals and alloys have been made. It is now well accepted that in the grain size regime up to about 50 nm the dislocation activity is significantly reduced. Other deformation mechanisms such as nucleation and motion of partial dislocations, grain boundary sliding or grain rotation and grain boundary motion were shown to gain importance, which is corroborated by the small activation volumes and increased strain rate sensitivity typically observed in nanocrystalline metals. In our work, we investigated nanocrystalline Pd und PdAu-alloys using strain rate sensitive indentation and micro-compression testing. In order to better understand the deformation mechanisms and their thermal activation, the experiments were conducted at different temperatures ranging from 10°C to 90°C. In this temperature range, no microstructural changes were observed. While the hardness was observed to increase with increasing alloying content, no significant alloying effect on the strain rate sensitivity and activation volume was observed at room temperature. For low alloying concentrations, the strain rate sensitivity and the apparent activation volume were observed to change with temperature.