MM 17 Symposium Severe Plastic Deformation IV

Time: Tuesday 14:45–17:30 Room: IFW A

Keynote Talk

MM 17.1 Tue 14:45 IFW A

Creep properties of ultrafine-grained metals — •Wolfgang Blum — University of Erlangen-Nürnberg, Inst. f. Werkstoffwissenschaften LS1, Martensstr. 5, 91058 Erlangen, Germany

At elevated temperatures ultrafine-grained (ufg) materials produced by severe plastic deformation attain a relative maximum of deformation resistance short after yielding. The relative maximum of flow stress at constant strain rate corresponds to a relative minimum in the rate of creep at constant stress. It is observed not only in tension, but also in compression and consequently respresents a deformation characteristic which is independent of fracture through necking, but means that deformation occurs close to steady state conditions where the dislocation structure is in a state of dynamic equilibrium of generation and annihilation of dislocations. The relatively high strain rate sensitivity of the flow stress corresponds to a low stress exponent of the creep rate. It is a major reason for the good ductility of ufg metals and even leads to superplastic behaviour in cases where the ufg structure is stable enough for the necessary rise in deformation temperature. The special properties of ufg metals come into apparence as the fraction of high-angle boundaries in the deformation induced subgrain structure becomes significant. They are explained by modification of dislocation structure evolution through relatively easy annihilation of dislocations at high-angle grain boundaries and direct strain contributions through grain boundary sliding and diffusive flow.

MM 17.2 Tue 15:15 IFW A

ECAP of magnesium alloys — •Mikhail V. Popov[1], Yuri Estrin[1], Ralph J. Hellmig[1], Lazar L. Rokhlin[2], and Sergey V. Dobatkin[2,3] — [1]Institut für Werkstoffkunde und Werkstofftechnik, Technische Universität Clausthal, Agricolastr. 6, 38678 Clausthal–Zellerfeld — [2]Baikov Institute of Metallurgy and Materials Science, Leninsky pr. 49, 119991 Moscow, Russia — [3]Moscow State Institute of Steels and Alloys (Technological University), Leninsk pr. 4, 119049 Moscow, Russia

The magnesium alloy MA17 (Mg-Ce-Mn) exhibits a high strength at a reasonable ductility making this alloy well suitable for structural applications. To further improve the mechanical properties, ECAP experiments at elevated temperatures (250°C) were carried out. For example, tensile tests at room temperature on specimens that had underwent 6 ECAP passes (route B_C) revealed a significant increase in yield strength. To substitute the expensive rare earth elements, a Mg-Ca-Al alloy was investigated as well. Results of the investigation of the mechanical properties at different temperatures for both alloys are discussed and compared.

MM 17.3 Tue 15:30 IFW A

Effect of Equal Channel Angular Pressing on the Deformation Behaviour of Magnesium Alloy AZ31 under Uniaxial Compression — •Zuzana Zúberová[1], Yuri Estrin[1], Torbjørn T. Lamark[1], Miloš Janeček[2], Ralph J. Hellmig[1], and Markus G. Krieger[1] — [1]Institut für Werkstoffkunde und Werkstofftechnik, Technische Universität Clausthal, Agricolastr. 6, 38678 Clausthal–Zellerfeld — [2]Charles University, Faculty of Mathematics and Physics, Ke Karlovou 5, 12116 Prague 2, Czech Republic

The deformation behaviour of the magnesium alloy AZ31 under uniaxial compression was investigated using specimens produced by squeeze casting, hot rolling and hot rolling with subsequent equal channel angular pressing (ECAP). ECAP was performed up to 4 passes at 200°C following route B_C leading to a homogeneous fine–grained microstructure and improved mechanical properties. Results of compression tests under various testing conditions as well as microstructural investigations are presented and discussed.

MM 17.4 Tue 15:45 IFW A

Microstructural, mechanical and thermal properties of ultrafine-grained Cu with and without dispersed nanosized Al2O3 particles — •Florian Dalla Torre[1], Chris H.J Davies[2], Elena V. Pereloma[2], and Jörg F. Löffler[1] — [1]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zürich, Wolfgang-Pauli-Str. 10, CH-8093 Zürich, Switzerland — [2]Victorian Centre for Advanced Materials Manufacturing and Department of Materials Engineering, Monash University, VIC, 3800, Australia

Pure Cu and Cu with 0.5 wt.% nanometer-sized Al2O3 particles were processed via equal channel angular extrusion (ECAE) up to 16 and 12 passes, respectively. Microstructural analysis of both materials indicates a strong change in texture, an increase in misorientation and a reduction in subgrain and grain size between the first and the fourth pass. With a higher number of passes a more equiaxed grain structure and decreasing cell-wall thickness evolves. After 16 passes several recrystallised grains, significantly larger than the surrounding grain size and with an abundance of Sigma 3 boundaries, were detected. The tensile tests performed show an increase in plastic strain and a reduction in strength after 4-8 passes. Additional compression tests were conducted to evaluate the work hardening and the strain-rate sensitivity (SSR) as a function of number of passes. The materials show elevated SSR and work-hardening stages III, IV and V. An evaluation of the hardening contributions accounting for the Al2O3 particles indicates a linear additive behaviour in the Orowan hardening and Hall-Petch hardening for the grain-size range studied.

Keynote Talk

MM 17.5 Tue 16:30 IFW A

Thermal stability of ultrafine grained materials produced by severe plastic deformation — •Günter Gottstein, Xenia Molodova, and Myrjam Winning — Institut für Metallkunde und Metallphysik, RWTH Aachen, 52056 Aachen, Germany

Equal-channel angular pressing (ECAP) has received considerable attention recently because it provides an easy means to produce an ultrafine grain size in bulk material for improved mechanical properties.

Despite much activity in this field, information on texture evolution during heat treatment is surprisingly sparse as compared to other aspects of ECAP. Comparatively little is known about the mechanisms of microstructural change during annealing. In Copper, a nonuniform coarsening leading to a duplex microstructure was reported by several authors and usually attributed to abnormal grain growth, but equally well it can be due to discontinuous recrystallization.

We investigated microstructure and texture evolution of Aluminium and Copper based materials after ECAP deformation and subsequent heat treatment. The deformed and annealed states were characterized by crystallographic texture analysis, EBSD measurements, microhardness tests and optical microscopy. Texture formation and microstructural changes were recorded and compared to other modes of large strain deformation. The annealing phenomena were analysed with respect to recrystallization and grain growth mechanisms. Theoretical concepts were developed and will be introduced to quantitatively account for the thermal stability of severely plastically deformed metallic materials.

MM 17.6 Tue 17:00 IFW A

Dilatometric studies on ECAP deformed Cu — •Kai Klement and Ferdinand Haider — University of Augsburg

By means of dilatometric measurements the excess volume of lattice defects in severely deformed Cu samples was investigated, in order to determine the type and concentration of these defects. Anisotropic behaviour and inhomogeneities where discovered.

High purity Cu (99.99%) was deformed by equal channel angular pressing for up to eight passes at room temperature, using 120° tooling, by either route A or B_C, generating high concentrations of non equilibrium defects. Annealing experiments with constant heat rate revealed shrinking of the samples in the order of 10^{-4} at temperatures between 180°C and 250°C, depending on the degree of deformation. The temperature characteristics of the annealing process did not provide any further information about different types of defects, showing only one sharp step in the dilatometer signal, which is in accordance with DSC, TEM and XRD investigations. Measurements along the three orthogonal directions of the die outlet channel showed significant differences in shrinking behaviour, indicating the annealing of anisotropic defect configurations like vacancy and dislocation agglomerates. In order to identify the nature of these defects, moleculardynamic simulations are planned, which provide the volumes of typical defect configurations.

MM 17.7 Tue 17:15 IFW A

Compaction of Amorphous and Partially Crystallised Al-Ni-La Alloys — •Jens Vierke, Markus Wollgarten, and John Banhart — Hahn-Meitner-Institute, Materials Dep., Glienicker Str. 100, D-14109 Berlin, Germany

Morphology, microstructure and crystallisation behaviour of Argon (Ar) and Helium (He) atomised $Al_{87}Ni_8La_5$ and $Al_{85}Ni_{10}La_5$ alloy powders were studied by scanning and transmission electron microscopy, X-ray diffraction (XRD) and differential scanning calorimetry. XRD measurements of He-atomised $Al_{85}Ni_{10}La_5$ powders show a complete X-ray-amorphous structure. Ar-atomised powders of the same alloy exhibit fcc-Aluminium crystals in an amorphous matrix. In the case of $Al_{87}Ni_8La_5$, the microstructure consists of an amorphous phase, fcc-Aluminium as well as intermetallic phases. DSC measurements reveal that the amorphous phase of all alloys is stable up to a temperature of about 170°C, applying a heating rate of 20 K/min. The powders were compacted by uniaxial pressing, direct extrusion and equal channel angular pressing. Different compaction temperatures were applied with regard to the conservation of the amorphous phase. First results of the study will be presented. The support of the Institute of Materials and Machine Mechanics of the Slovak Academy of Sciences is gratefully acknowledged.