MM 45 Mechanical Properties III

Time: Friday 12:30–13:30 — Room: IFW A

MM 45.1 Fri 12:30 IFW A

Intrinsic plastic deformation behaviour of the complex metallic alloy phase ß-Al-Mg — •Stefan Roitsch, Marc Heggen, Carsten Thomas, Marita Schmidt, and Michael Feuerbacher — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

We have performed macroscopic plastic deformation experiments on the complex metallic alloy ß-Al-Mg. This material is a technologically interesting lightweight alloy (density 2.2 g/cm3) with a face centred structure containing about 1168 atoms per unit cell. For the first time, the intrinsic plastic deformation behaviour of high-quality single crystalline material was characterized. Uniaxial deformation experiments at a constant strain rate of 10-4 s-1 were performed at temperatures between 225 and 375°C. It was found that the single crystalline ß-Al-Mg exhibits ductile behaviour down to temperatures of 225°C. At this temperature we find upper yield stresses of about 780 MPa. This is a very high value compared to other alloys in the Al-Mg system, for which yield stresses of the order of 300 MPa and below are found. The yield-point is followed by an almost constant flow-stress level up to strains of about 6%. Stress-relaxation tests and temperature changes were carried out in order to determine the thermodynamic activation parameters of the deformation process.

MM 45.2 Fri 12:45 IFW A

Strain rate effects of nano- and microcrystalline nickel measured form the macro- to the nanoscale — •Horst Vehoff, Delphine Lemaire, Bo Yang, and Michael Marx — Saarland University, Department of Materials Science, Building D23, D-66041 Saarbrücken, Germany

Understanding the macroscopic deformation behaviour of metals based on the microscopic mechanisms like grain rotation, grain boundary- and volume diffusion, emission and motion of dislocations and the interaction of dislocations with microstructure elements is one of the main objectives of modern materials science. Due to the different length scales of the deformation mechanisms the active mechanisms change with the grain size. Therefore the grain size dependent deformation behaviour was investigated locally by nanoindentation and macroscopically by incremental strain rate tests with nanocrystalline and microcrystalline nickel. The nanoindentation measurements probe the interaction of dislocations and grain boundaries locally during plastic deformation. It will be shown that with decreasing grain size the pile up of dislocations at grain boundaries as the dominant mechanism of the deformation process which leads to hardening is changed to grain boundary sliding and grain rotation as active mechanisms which leads to softening. The measurements were completed by macroscopic measurement of the strain rate sensitivity as function of the grain size. It will be shown that nanocrystalline materials have a higher strain rate sensitivity and smaller activation volumes than microcrystalline materials which indicates a continuous change of deformation mechanisms with the grain size.

MM 45.3 Fri 13:00 IFW A

High compression strain in bulk metallic glass composites containing low fraction of nanocrystals — •Alban Dubach, Florian Dalla Torre, Marco Siegrist, Kaifeng Jin, and Jörg F. Löffler — Laboratory of Metal Physics and Technology, Department of Materials, ETH Zürich, Wolfgang-Pauli-Str. 10, CH-8093 Zürich, Switzerland

A significant difference in compression strain but a similar yield strength has been measured for Zr-based bulk metallic glasses, if cast using two different techniques (casting via arc melting or induction melting). The processing route via arc melting produces samples showing plastic compression strains of 10-20%, whereas the other generates samples with only 0-2% plasticity. Microstructural analysis shows that despite the good glass-forming ability of the alloys chosen, samples with high compressive strain contain nanosized crystals in a glassy matrix. These samples are x-ray amorphous, while transmission electron microscopy clearly reveals the presence of a low fraction of nanocrystals. In contrast, the samples processed via induction melting are fully amorphous, but less ductile. We suggest that the second-phase nanoparticles, despite their low volume fraction not detectable by x-ray diffraction, lead to nucleation and multiplication of shear bands, in turn producing high plastic strain. Such high plasticity allows 'in-situ' probing of deformation kinetics by cycling the strain rate during compression testing. Results show a negative strain-rate sensitivity, which tends to be more pronounced for samples containing a higher fraction of second-phase particles or tested at higher strain rates.

MM 45.4 Fri 13:15 IFW A

Room-temperature embrittlement of Mg-based amorphous alloys — •A. Castellero, D.I. Uhlenhaut, and J.F. Löffler — Laboratory of Metal Physics and Technology, ETH Zürich, Wolfgang Pauli Str. 10, 8093 Zürich, Switzerland

Mg-Cu-Y alloys can be amorphised in a wide range of compositions. When these alloys are produced in bulk form they exhibit high mechanical strength but no ductility. Rapidly quenched ribbons and thin foils show plastic deformation upon bending. However, a dramatic deterioration in mechanical properties is observed after aging at room temperature. A sharp transition from ductile to brittle behaviour can be observed in Mg65Cu25Y10 a few hours after the alloy has been produced. The process becomes slower when Cu is substituted by Mg. Corresponding to this time-dependent embrittlement, differential scanning calorimetry (DSC) curves show a reduction in the relaxation enthalpy that is associated with a structural relaxation (i.e. annihilation of free volume) of the metallic glass. Oxidation as a cause of this embrittlement has been ruled out, since the same behaviour is observed when the samples are stored in a protective atmosphere. The bent as-quenched samples exhibit shear bands on the surface, indicating that the material is able to deform plastically. The aged metallic glass exhibits only elastic deformation, followed by catastrophic failure at a certain critical bending strain which progressively decreases with time. The mechanical properties and the deformation mode were characterized in detail as a function of time.