MM 12 Symposium Severe Plastic Deformation III

Time: Tuesday 10:15–12:45 Room: IFW A

Keynote Talk MM 12.1 Tue 10:15 IFW A

Scaling Effects on the Plasticity of ECAP Nickel — •Lutz Hollang[1], Ellen Hieckmann[2], Dieter Brunner[3], Carl Holste[1], and Werner Skrotzki[1] — [1]Institut für Strukturphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Institut für Angewandte Physik, Technische Universität Dresden, 01062 Dresden, Germany — [3]Max-Planck-Institut für Metallforschung, Heisenbergstrasse 3, 70569 Stuttgart, Germany

The influence of grain size on the interaction mechanisms between dislocations governing the plastic behaviour of fcc metals at low temperatures was studied by means of thermal activation analysis. For this purpose the plastic behaviour of sub-microcrystalline (smc) nickel processed by equal-channel angular pressing (ECAP) was investigated in tension at constant temperatures between 4 K and 320 K. Stress-relaxation experiments performed during the tensile tests were used to determine the rate sensitivity of the material as a function of the flow stress. In all cases the relationship is found to be linear revealing that the mean dislocation spacing influences both, the athermal and thermal contribution to the flow stress in the same manner as predicted by the Cottrell-Stokes law. The effect of grain size on the flow stress can be attributed to a constant additive athermal stress contribution. Moreover, the thermal activation analysis indicates that at temperatures below 100 K a local single slip mechanism governs the plastic behaviour of smc ECAP nickel. At higher temperatures other thermally activated slip processes become rate controlling. They are probably connected with the thermally activated dissolution of the initial ECAP structure.

Keynote Talk MM 12.2 Tue 10:45 IFW A

Large plastic deformation of binary FeCr alloys - a new approach to understand the creep properties of tempered martensite ferritic steels — •Gunther Eggeler — Institut für Werkstoffe, Ruhr-Universität Bochum, Germany

In the present study we use equal channel angular pressing (ECAP) to strongly deform a binary Fe10Cr alloy. The ECAP parameters are adjusted such that the Fe10Cr alloy develops an ultra fine grained microstructure which appears to be very similar to the microstructure of a tempered martensite ferritic reference steel (German grade X20). We use transmission (TEM) and scanning electron microscopy with orientation imaging (SEM&OIM) to investigate grain sizes, grain shapes and grain orientations in both materials. While the two materials show very similar ultra fine grain microstructures, the grain boundaries of X20 are stabilized by carbides. We perform creep experiments on both materials and compare creep curves as well as the evolution of microstructures during creep. The results show how imported boundary carbides are in providing the good creep resistance of tempered martensite ferritic steels. The martensitic transformation (accompanied by strong internal stresses and strains) which represents an essential first step in the heat treatment of tempered martensite ferritic steels and the subsequent aging result microstructures which in the absence of a martensitic transformation can only be established by severe plastic deformation.

Keynote Talk MM 12.3 Tue 11:45 IFW A

Fatigue Behaviour of Ultrafine Grained BCC and FCC Materials — •Hans J. Maier[1] and Heinz Werner Höppel[2] — [1]Lehrstuhl für Werkstoffkunde, Universität Paderborn — [2]Lehrstuhl Allgemeine Werkstoffeigenschaften, Universität Erlangen-Nürnberg

The present study reports on the fatigue behaviour of ultrafine grained materials with BCC (interstitial free (IF) steel) and FCC (copper and aluminium) structure. The ultrafine microstructures were obtained using equal channel angular extrusion (ECAE) at room temperature. Low-cycle fatigue tests were conducted in total strain-controlled fully reversed push-pull loading. Transmission electron microscopy was employed to characterize microstructural evolution. Cyclic stress-strain response was monitored both in constant amplitude tests and incremental step tests. Stable cyclic stress-strain response was observed for optimized ECAE routes. For ultrafine grained FCC materials, ECAE processing is commonly reported to result in an increase in cyclic strength but a decrease in fatigue life when compared with unprocessed material. By contrast, a more than two-fold increase in strength and number of cycles to failure was observed after optimum ECAE processing of the IF steel in the current study. In addition, in-situ fatigue tests were conducted in an environmental SEM to understand the substantially different fatigue behavior of the ECAE-processed materials. The implications of the damage mechanisms observed are discussed with respect to optimization of ultrafine microstructures.

Keynote Talk MM 12.4 Tue 12:15 IFW A

Cylic Deformation Behaviour and Fatigue Life of Ultrafine-Grained Aluminum — •Dorothea Amberger, Johannes May, Heinz-Werner Höppel, and Mathias Göken — Lehrstuhl Allgemeine Werkstoffeigenschaften, Martensstrasse 5, 91058 Erlangen

Bulk ultrafine-grained (UFG) metals with grain sizes in the submicrometer range can be produced by Equal Channel Angular Pressing. Generally UFG materials exhibit extraordinary mechanical properties [1,2], and show also an enhanced strain rate sensitivity (SRS). The mechanisms responsible for the SRS, like Coble creep, grain boundary sliding or thermally activated annihilation of dislocations [1,2,3,4], are still unclear. This work focuses on the influence of the strain rate of UFG Al under cyclic loading. The obtained stress amplitudes for the tests performed at a smaller strain rate are only smaller within the first hundred cycles. This is in accordance to the observations under monotonic loading. After the first hundred cycles no significant differences between the obtained stress amplitudes with respect to the strain rate were found. Based on these results it can be concluded that grain boundary sliding or coble creep cannot be the relevant mechanisms for SRS, as there is no reasonable explanation for the diminishing of the difference in the stress amplitudes during cycling. In contrast, annihilation of dislocations can quite reasonably explain these results.

[1] RZ Valiev, IV Alexandrov; J Mater Res 2002 17 (1) 5 [2] HW Höppel, J May, M Göken; Adv Eng Mater 2004 6 781 [3] YJ Li, XH Zeng, W Blum; Acta Mater 2004 52 5009 [4] J May, HW Höppel, M Göken; Scripta Mater 2005 53 189