MM 14: Topical Session Bulk Nanostrucured Materials III - Microstructure and Characterization I

Time: Monday 15:45–17:15 Location: H 0107

MM 14.1 Mon 15:45 H 0107

Absolute concentration of free volumes and related properties of ultrafine grained metals studied by time-dependent dilatometry — Bernd Oberdorfer[1], •Eva-Maria Steyskal[1], Wolfgang Sprengel[1], Michael Zehetbauer[2], Reinhard Pippan[3], and Roland Würschum[1] — [1]Inst. f. Materialphysik, TU Graz, Graz, Austria — [2]Physik Nanostrukturierter Materialien, Fak. f. Physik d. Universität Wien, Wien, Austria — [3]Erich Schmid Inst. of Materials Science, Leoben, Austria

Time-dependent dilatometry provides a direct approach to the absolute concentration of free volumes in nanophase materials, as it allows for a real-time observation of irreversible macroscopic length changes due to the annealing out of free volumes upon heat treatment. The ultrafine grained metals presented in this work were produced by severe plastic deformation via the high pressure torsion method. The annealing stages observed upon linear heating of severely plastically deformed iron, tantalum, copper, and nickel allow for an investigation of the absolute concentration as well as the kinetics of free volume type defects such as vacancies, dislocations, and grain boundaries [1]. Moreover a direct approach to the physical key parameter of specific grain boundary excess volume will be presented, using ultrafine grained nickel as a model system [2]. Financial support by the FWF Austrian Science Fund is appreciated (project P21009-N20).

[1] B. Oberdorfer et al., J. Alloys Comp. **509**, 309 (2011)

[2] E.-M. Steyskal et al., Phys. Rev. Lett, *in press*

MM 14.2 Mon 16:00 H 0107

Re-ordering of FeAl made nanocrystalline by high pressure torsion — •Christoph Gammer, Clemens Mangler, Hans-Peter Karnthaler, and Christian Rentenberger — University of Vienna, Physics of Nanostructured Materials, 1090 Wien, Austria

In this work bulk intermetallic FeAl is made nanocrystalline by high pressure torsion deformation of a B2 ordered Fe-45at.%Al alloy. In the literature it was reported that in FeAl the long-range order is lost during deformation as indicated from X-ray measurements. In contrast, the present work shows that the disorder is not complete since it is revealed by TEM methods that chemically ordered nanodomains of about 2nm are observed after deformation [1]. Upon heating the long-range order is recurring by coarsening of the ordered nanodomains until they reach the grain size. Based on the coarsening of the chemically ordered nanodomains a model for the reordering process is developed and fitted to the results yielded from differential scanning calorimetry. This model allows to determine the vacancy concentration, the vacancy migration enthalpy and the vacancy migration volume. Finally, by annealing of specimens deformed by high pressure torsion without unloading, i.e. maintaining the hydrostatic pressure, their vacancy concentration is determined and compared to that after unloading. This leads to the result that vacancy relaxation occurs during unloading.

[1] C. Gammer, C. Mangler, H. P. Karnthaler, C. Rentenberger. Scripta Mater. 65, 57 (2011).

This work was supported by the Austrian Science Fund (FWF):[S10403,P22440].

MM 14.3 Mon 16:15 H 0107

High-pressure torsion induced open volume defects in Al-3wt%Cu investigated by positron annihilation spectroscopy — •Peter Parz[1], Michael Faller[2], Reinhard Pippan[2], Werner Puff[1], and Roland Würschum[1] — [1]Institut für Materialphysik, Technische Universität Graz, Petersgasse 16, 8010 Graz, Austria — [2]Erich Schmid Institute of Materials Science, Austrian Academy of Sciences and Department Materials Physics, University of Leoben, A-8700 Leoben, Austria

High-pressure torsion (HPT) has proven its capability to refine metals down to grain sizes of approximately 100nm [1]. In the case of age-hardenable aluminium alloys HPT deformation may significantly affect the process of precipitation hardening. In present work [2], an Al-3wt%Cu alloy was solution treated and quenched and subsequently subjected to HPT deformation. The defect structure and its annealing behaviour have been investigated by positron annihilation lifetime spectroscopy (PALS) and the chemical sensitive method of 2-dimensional Doppler broadening spectroscopy (2d-DB). Significant deviations of the mean positron lifetime and the chemical environment of the positron trapping sites due to HPT were detected.

[1] R. Pippan, F. Wetscher, M. Hafok, A. Vorhauer, I. Sabirov: The Limits of Refinement by Severe Plastic Deformation, Adv. Eng. Mater., 2006, 8, 11

[2] P. Parz, M. Faller, R. Pippan, W. Puff, R. Würschum: Microstructure and vacancy-type defects in Al-3wt%Cu after high-pressure torsion, Physics Procedia, accepted

MM 14.4 Mon 16:30 H 0107

DSC investigations on lattice defects in hydrogenated Pd processed by High Pressure Torsion — •Daria Setman, Maciej Krystian, Matthias Bönisch, Gerhard Krexner, and Michael Zehetbauer — Faculty of Physics, University Vienna, Austria

Disk-shaped Pd (99.95%) samples (diameter 6mm, thickness 0.8mm) were loaded with hydrogen in a Sieverts-type apparatus up to a hydrogen content [H]/[Pd]˜0.78. HPT-processing was performed at 195 K and 8 GPa hydrostatic pressure. DSC and TEM measurements revealed - for the first time - evidence of vacancy-hydrogen (Vac-H) clusters being formed during HPT. The vacancy densities from clusters reach atom concentrations as high as of order 10-3, and are thermally stable till 483 K (i.e. by 110 K higher than for undeformed Pd). Hydrogen desorption was monitored by microhardness and density measurements confirming effects typical of defect clusters on the mechanical properties. Results also demonstrate that hydrogen-assisted thermal stabilization not only occurs with vacancy-type defects but also with dislocations and grain boundaries, thus suggesting this effect for stabilization of nanocrystalline materials in general. However, prompt-gamma activation analysis showed that during annealing at RT for one year, the hydrogen desorbs completely, also including the part which had been trapped in the Vac-H-clusters.

[1] M. Krystian, D. Setman, B. Mingler, G. Krexner, M. J. Zehetbauer, Scripta Mater. 62, (2010) 49-52

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MM 14.5 Mon 16:45 H 0107

Self-similarity in junction controlled grain growth — •Dana Zöllner and Peter Streitenberger — Abteilung Materialphysik, Institut für Experimentelle Physik, Otto-von-Guericke-Universität, 39106 Magdeburg

The question of self-similarity in normal grain growth and particle coarsening has been a topic of research for decades, where statistical self-similarity was either found as an observation in experiments and simulations or used as an assumption for theoretical considerations. In the present work we show that self-similarity is also a feature of junction limited grain growth as it can be found in nanocrystalline materials. To that aim we analyse the influence of the various grain boundary junctions on grain growth kinetics by attributing to each type of boundary junctions an own specific energy and mobility resulting in nine types of growth kinetics each characterised by a self-similar scaling form of the growth law and corresponding self-similar grain size distribution function. In particular, for the cases of grain boundary, triple line and quadruple point mobility controlled grain growth the analytical model is in excellent agreement with the results of a modified Monte Carlo Potts model simulation based on a limited mobility of the boundary junctions.

MM 14.6 Mon 17:00 H 0107

Laser ultrasound for evaluation of microstructure of HPT nickel — Victor V. Kozhushko[1], •Heinz Krenn[1], and Reinhard Pippan[2] — [1]Karl-Franzens-University Graz, Graz, Austria — [2]Erich Schmid Institute, Austrian Academy of Sciences, Leoben, Austria

The high pressure torsion (HPT) method is employed for grain size refinement of polycrystalline nickel. The grain structure of a disk specimen of about 30 mm diameter and 2.5 mm thickness is changed from coarse grains at the center to ultrafine grains (150 nm) at the periphery of the HPT-sample. The evaluation of the elastic properties was carried out by means of laser induced ultrasound. A noncontact sensor (5 mm pancake coil) based on an electromagnetic acoustic transducer (EMAT) and a permanent cylindrical magnet with the field of ˜0.25

T was attached to one side of the specimen. The coil detects the transient magnetic field due to the inverse magnetostrictive effect from the pressure pulse excited by the laser. The pronounced compression phase has nanosecond duration. The attenuation of the propagating ultrasound pulse is mainly due to the interaction with dislocations [1]. The scattering at grain boundaries produces longitudinal and shear waves which arrive to the sensor later than the primary pulse. Signals measured at different radii of the nickel specimen clearly showed a decrease of the ultrasonic attenuation with the HPT-refinement of the microstructure.

Financial support by the FWF Austrian Science Fund is appreciated (No. S10407-N16).

[1] V.V. Kozhushko et al., Key Eng. Mat. 465 (2011) 374