MM 41: Electron Microscopy

Time: Wednesday 15:45–17:15 Location: TC 006

MM 41.1 Wed 15:45 TC 006

Five-fold dissociation of dislocations in the hexagonal complex metallic alloy my-AlMn — •Marc Heggen, Stefan Roitsch, and Michael Feuerbacher — Ernst Ruska Centrum, Forschungszentrum Juelich GmbH, 52425 Juelich, Germany

Complex metallic alloys (CMAs) are a class of intermetallics characterized by a high structural complexity, large lattice parameters, and a multitude of atoms per unit cells. In recent years, novel complex defects and new mechanisms of plastic deformation have been reported in these alloys. In this contribution defects in the CMA my-AlMn, a hexagonal phase (space group P63/mmc) with 563 atoms per unit cell and lattice parameters a=2.0 nm and c=2.5 nm are investigated. Using state-of-the-art aberration-corrected scanning transmission electron microscopy, the atomic dislocation and stacking fault structure is studied in plastically deformed my-phase samples. We demonstrate the existence of groups of five dissociated dislocations, having [0 0 1] line direction. The dislocations are partials connected by complex stacking faults with typical overall splitting distance of 100 nm employing two different types of hexagonal structural subunits.

MM 41.2 Wed 16:00 TC 006

Effect of severe plastic deformation on Al3Sc precipitation in an Al-Mg-Mn-Sc alloy — •Yulia Buranova[1], Anna Mogucheva[2], Harald Rösner[1], Ankit Gupta[3], Tilmann Hickel[3], Sergiy V. Divinski[1], and Gerhard Wilde[1] — [1]Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str.10, 48149 Münster, Germany — [2]Belgorod State University, 85 Pobedy, 308015 Belgorod, Russia — [3]Max-Planck-Institut für Eisenforschung GmbH, 40237 Düsseldorf, Germany

Aluminum alloys containing scandium show excellent mechanical properties due to the presence of Al3Sc precipitates. In this study the effect of severe plastic deformation using equal channel angular pressing (ECAP) on the formation of Al3Sc precipitates has been investigated. The grain size, dislocation density, particles size, chemistry and particle distribution were investigated by analytical transmission electron microscopy. Additionally, geometric phase analysis (GPA) was applied to map local strains. The chemical mapping reveals a uniform distribution of Mg in the Al matrix. Three types of precipitates are generally found. The smallest particles, mostly Al3Sc, are coherent with sizes of 5-10 nm. Precipitates around 15-30 nm are found to contain Al, Mg, Mn and Sc. Larger particles contain mainly Al and Mn. These chemical trends are compared with ab initio calculations. While the middle- and large-size precipitates are predominantly found along grain boundaries and dislocation lines in their initial state, the ECAP processing produces an almost uniform distribution of particles. The experimental findings are compared with predictions based on atomistic simulations.

MM 41.3 Wed 16:15 TC 006

Comprehensive model of metadislocation motion in o-$Al_{13}Co_4$ — •Markus Heidelmann, Marc Heggen, Christian Dwyer, and Michael Feuerbacher — Ernst-Ruska-Centrum, Forschungszentrum Jülich, 52425 Jülich, Deutschland

In several complex metallic alloys plastic deformation is mediated by metadislocations. Due to the complex nature of these defects and the large number of atoms in their core region, little is known about the atomic rearrangements taking place during movement of a metadislocation. In this work we report on the first development of a fully three-dimensional model of a moving metadislocation including all atomic species. The CMA chosen for our study is the moderately complex o-$Al_{13}Co_4$, an orthorhombic phase with 102 atoms per unit cell. Using a combination of high-resolution scanning transmission electron microscopy and density functional theory, we have developed an atomic model for the [010] glide movement of a metadislocation in $Al_{13}Co_4$ extending to light elements and including the third dimension. Metadislocation movement was analysed employing a simulated-annealing procedure to minimize the total jump distance of all atoms within the model. While the distance of one glide step is 12.3 Å, the maximum jump distance of an individual atom is a much more moderate 3.4 Å. The approach described is versatile enough to be applied to other, more complex problems, for example metadislocation movement in ϵ_6-Al-Pd-Mn.

We kindly acknowledge funding from the DFG under project Pak 36 / FE 571/2-2.

MM 41.4 Wed 16:30 TC 006

Crystallization of amorphous FeNiP nanowire arrays studied by in-situ TEM — Nina Winkler, •Martin Peterlechner, and Gerhard Wilde — Institut für Materialphysik, Westfälische-Wilhelms-Universität Münster, NRW

Nano-scaled magnetic materials are in focus of basis research since decades, and of remarkable technical importance. In this work, an array of amorphous soft magnetic nanowires was successfully processed using porous Anodic Alumina Oxide (AAO) templates. This enables to study the crystallization in confined volumes and to control the regularity and shape of the nanostructures via the AAO pores which are uniform in length and diameter. Fe40Ni40P20 (at. %) nanowire arrays were processed into the AAO pores by electrodeposition. Differential scanning calorimetry (DSC) of a likewise processed thin film shows a glass transition. Upon in-situ annealing in the transmission electron microscope (TEM) the microstructural evolution can be detected. Crystallization kinetics includes long range diffusion and a high nucleation rate. Annealing at temperatures above the crystallization temperature follows a phase separation of FeNiP in multilayers of FeNi and FeNiP phases. The impact of different heating rates on the phase evolution is studied by DSC. The obtained magnetic properties are characterized by a Vibrating Sample Magnetometer (VSM).

MM 41.5 Wed 16:45 TC 006

Determination of local density in amorphous materials based on HAADF-STEM signals — •Lea Kümper[1], Vitalij Schmidt[1], Harald Rösner[1], Martin Peterlechner[1], Tobias Brink[2], and Gerhard Wilde[1] — [1]Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Germany — [2]Institut für Materialwissenschaft, Technische Universität Darmstadt, Germany

It was shown that in metallic glasses narrow zones with different densities in comparison to the surrounding matrix are formed during plastic deformation. These deformation zones are called shear bands. Using high-angle annular dark field scanning transmission electron microscopy (HAADF-STEM) it is possible to quantify the local density changes in amorphous materials and thus in shear bands [1]. The quantification of the local density change ρ was based on the approximation that the density change can be calculated according to: $\Delta\rho = \frac{\rho_1-\rho_2}{\rho_2} \cong \frac{I_1 x_k^1 t_2}{I_2 x_k^2 t_1} - 1$, where ρ is the density, x_k is the contrast thickness and t is the foil thickness for different zones in a sample. In this contribution the reliability of this approximation is investigated experimentally using amorphous Si-Ge multilayer systems as calibration standards. Additionally, we obtained Cu-Zr glass structures with shear bands by molecular dynamics computer simulations. These were used to obtain the corresponding HAADF-STEM images via image simulation. The obtained results are discussed with respect of the accuracy of the density determination method. [1] H. Rösner et al., Ultramicroscopy, 142 (2014)

MM 41.6 Wed 17:00 TC 006

Comparison of medium-range order in shear bands and matrix of a metallic glass by fluctuation electron microscopy — •Vitalij Schmidt[1], Harald Rösner[1], Martin Peterlechner[1], Paul Voyles[2], and Gerhard Wilde[1] — [1]Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — [2]Materials Science and Engineering, University of Wisconsin-Madison, 1509 University Ave, Madison, WI53706, USA

The deformation behavior of metallic glasses is yet not fully understood. For temperatures well below the glass transition and high strains the plastic flow is restricted to narrow areas called shear bands while the surrounding amorphous matrix seems unaffected. Thus modifications of the local medium-range order (MRO) are likely to be expected in the shear bands. In order to analyze the structural modifications in shear bands directly, melt-spun and subsequently cold-rolled $Al_{88}Y_7Fe_5$ ribbons were selected and prepared for transmission electron microscopy (TEM) by electro-polishing. The thin foils exhibit shear bands with contrast changes along their propagation direction observed by high-angle annular dark-field (HAADF)-STEM. Fluctua-

tion electron microscopy has been used to characterize the deformed metallic glass samples by analyzing sets of nanobeam-diffraction patterns. Azimuthal profiles are extracted from the variance of these sets resulting in a measure for the MRO. Different parts of the observed shear bands are compared with the surrounding matrix showing differences in MRO with respect to the contrast changes.