MM 40: Topical session: In-situ Microscopy with Electrons, X-Rays and Scanning Probes in Materials Science IV - Atomic structure and defects III

Time: Wednesday 15:45–18:00 Location: H38

Topical Talk MM 40.1 Wed 15:45 H38

Mapping local transient strain fields during in situ TEM deformation — •Christoph Gammer — University of Vienna, Physics of Nanostructured Materials — NCEM, Molecular Foundry, Lawrence Berkeley National Laboratory

While in situ TEM has provided insight into fundamental deformation mechanisms, the local strain during plastic deformation is of great importance to correlate defect structure with material properties.

In the present work we show that strain mapping can be carried out during continuous in situ deformation in a TEM at the nanometer scale. Two different types of tests are demonstrated. In the case of crystalline samples, our method is based on STEM diffraction mapping [1,2]. A direct electron detector is used to acquire diffraction patterns at a faster rate. Time resolved strain maps recorded during in situ deformation of an Al sample allow to measure local and transient strains occurring around moving dislocations. In addition an amorphous metallic glass sample was deformed in tension. For this experiment digital image correlation of decorated samples was used to obtain the time dependent local strain map revealing extreme localization of the deformation.

1. C. Gammer et al., Ultramicroscopy 155 (2015) 1.
2. V.B. Ozdol et al., Appl. Phys. Lett. 106 (2015) 253107.

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MM 40.2 Wed 16:15 H38

In-situ TEM isothermal annealing of nano-crystalline supersaturated Cu-Cr thin film alloys — •Tristan Harzer, Jazmin Duarte, and Gerhard Dehm — Max-Planck-Institut für Eisenforschung GmbH, Structure and Nano-/Micromechanics of Materials, Max-Planck-Strasse 1, 40237 Düsseldorf, Germany

The thermal stability and decomposition behavior of nano-crystalline single-phase Cu-Cr thin film alloys grown far from equilibrium were investigated by isothermal heat treatments. In the as-deposited state, the alloy films exhibit supersaturated solid solutions with a fcc and bcc structure for alloy compositions containing 4 at.% and 33 at.% Cr, respectively. Isothermal annealing in a temperature range of 150 °C - 500 °C were conducted inside a TEM and compared to phase stability data obtained by XRD under comparable annealing conditions. It is shown that the single phase nature of the alloy films is maintained for annealing temperatures of up to 300 °C, whereas heat treatment at temperatures of 400 °C or higher results in the formation of the two phase equilibrium film structures. Film decomposition in case of the Cu-4 at.% Cr thin film alloy proceeds via enrichment of Cr at grain boundaries and grain boundary diffusion whereas phase separation of the Cu-33 at.% Cr thin film alloy progresses predominantly via volume diffusion. Temperature dependent diffusion coefficients for volume and grain boundary diffusion along with the respective activation energies are determined from analytical in-situ TEM. In addition, the influence of electron beam irradiation on the diffusion kinetics is considered.

MM 40.3 Wed 16:30 H38

Assessing phase stability and element distribution in Co-base superalloys at elevated temperatures by in situ TEM heating experiments. — •Yolita Eggeler, Julian Müller, and Erdmann Spiecker — Lehrstuhl für Mikro- und Nanostrukturforschung & Center for Nanoanalysis and Electron Microscopy (CENEM), Department Werkstoffwissenschaften, Universität Erlangen-Nürnberg, Cauerstraße 6, 91058 Erlangen

Co-based alloys, of a composition of Co-12Al-9W, form a stable two phase γ/γ' microstructure at 900 °C [1]. γ' cubes, consisting of the L12 crystal structure are coherently embedded in a solid solution fcc (A1) γ matrix. To ensure precipitate hardening at temperatures, which are relevant to practical applications, 700-1100 °C, as experienced in gas turbine applications, the stability of the γ/γ' phases is of fundamental importance. In this analysis in situ TEM studies with chip-based heating systems (by DENS solution) are applied on new Co-based superalloys. After in situ heating at apr. 900 °C and controlled quenching with different quenching rates the elemental distribution at the γ/γ' interface is measured using ChemiSTEM EDX. Exploiting the driving force for interface movement resulting from temperature-dependent volume fraction of γ and γ' insight into the diffusion of individual alloying elements and the relationship between local chemistry and ordering can be gained from transient phenomena. The experimental results will be compared with theoretical calulations. This work has been carried out within the framework of the SFB-TR 103 "Single Crystal Superalloys". [1] J. Sato et al, Science (2006), vol.312, p. 90

15 min. coffee break

MM 40.4 Wed 17:00 H38

Nanostructured Metallic Glasses: Tailoring the Mechanical Properties of Amorphous Metals — •Karsten Albe, Tobias Brink, and Omar Adjaoud — TU Darmstadt, Fachbereich Material -und Geowissenschaften, FG Materialmodellierung, Jovanka-Bontschits-Str. 2, D-64287 Darmstadt

The mechanical properties of metallic glasses can not only be influenced by their chemical composition, but also by their nanostructure: Secondary phases in the form of precipitates, as well as a glass-glass interfaces are possible means to enhance the plasticity of the material. In this contribution results from molecular dynamics simulations of nanostructured Cu-Zr based metallic glasses under external load will be discussed and compared with experimental findings, especially with results from transmission electron microscopy. The influence of crystalline nanoprecipitates on shear band nucleation and propagation is investigated, and also the effect of grain size and composition on the deformation behavior of nanoglasses and nanoglass composites.

MM 40.5 Wed 17:30 H38

Medium range order in Pd-based glasses — •Vitalij Schmidt[1], Harald Rösner[1], Martin Peterlechner[1], Gerhard Wilde[1], and Paul Vayles[2] — [1]Insitut für Materialphysik, Universität Münster — [2]Materials Science and Engineering, University of Wisconsin-Madison

Metallic glasses exhibit superior mechanical properties like high yield strength or wear and corrosion resistance. However after a large elastic regime they are prone to catastrophic failure especially under tensile load. This motivates an interest in understanding the deformation behavior of metallic glasses. Deformation tests on metallic glasses performed well below the glass transition temperature have shown that the plastic flow is restricted to narrow regions called shear bands. They are associated with a structural changes (free volume) compared to the surrounding matrix due to shear localization. Thus modifications of the local short or medium range order (SRO, MRO) are expected in shear bands.

In order to study directly the structural changes fluctuation electron microscopy (FEM) has been used to characterize Pd-based metallic glass samples by analyzing sets of nanobeam diffraction patterns (NBDPs). The variance of the individual patterns were extracted from azimuthal profiles and normed be the mean intensity squared. This way a directly comparable normalized variance is obtained. Samples of different states (as-cast, deformed, annealed) and chemical compositions (micro-alloying) are compared.

MM 40.6 Wed 17:45 H38

Analysis of local atomic arrangement in layered Ge-Sb-Te crystal structures by advanced scanning transmission electron microscopy — •Andriy Lotnyk, Ulrich Ross, Sabine Bernütz, Erik Thelander, and Bernd Rauschenbach — Leibniz Institute of Surface Modification (IOM), Permoserstr. 15, D-04318 Leipzig, Germany

The knowledge on the proper local atomic arrangement in Ge-Sb-Te compounds is of particular interest for optical and electronic applications such as data storage, thermoelectric and ferroelectric. In this work, we study the local atomic arrangements in Ge-Sb-Te thin films consisting of layered $Ge_2Sb_2Te_5$, $Ge_1Sb_2Te_4$ and $Ge_3Sb_2Te_6$ crystal structures by using state of the art atomic-resolution aberration-corrected (Cs-corrected) high-angle annular dark-filed scanning transmission electron microscopy (HAADF-STEM) and proper theoretical image simulations. The results show that the intensities in simulated Cs-corrected HAADF-STEM micrographs are very sensitive to thermal displacement factors in the studied structures at specific lattice sites. Based on these findings, we are able to determine proper stack-

ing sequences in the Ge-Sb-Te phases by comprehensive analyses of experimental and simulated image intensities. The experimental data reveal that the Ge and Sb atomic species tend to form intermixed cation layers which differ from theoretical predictions. However, the ratio of Sb to Ge is different in distinct cation layers. The obtained data are discussed with respect to existing experimental and theoretical structure models reported for bulk Ge-Sb-Te materials.