MM 4: Microstructure and Phase Transformations - Characterization

Time: Monday 10:15–11:30 Location: IFW B

MM 4.1 Mon 10:15 IFW B

Spatial correlations between strengthening phases in hardenable aluminum alloys — •Viktor Wessely[1], Robin Schäublin[1], Stephan S. A. Gerstl[1,2], Stefan Pogatscher[3], Peter J. Uggowitzer[1], and Jörg F. Löffler[1] — [1]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zurich, 8093 Zurich, Switzerland — [2]Scientific Center for Optical and Electron Microscopy, ETH Zurich, 8093 Zurich, Switzerland — [3]Nonferrous Metallurgy, Montanuniversitaet Leoben, 8700 Leoben, Austria

We focus on a new generation of hardenable aluminum alloys based on the concept of high-strength Al–Sc alloys that form coherent Al_3X $L1_2$-structured precipitates. Suitable candidates other than Sc are rare-earth or transition metals, such as Er, Zr, Hf or Yb, which have been shown to strengthen the material while simultaneously providing improved high-temperature stability. In this study we deployed thermodynamic and kinetic modeling to design alloys and their heat treatments, with subsequent mechanical and microstructural characterization. The dispersoids form as a coherent ordered phase within the fcc matrix. Studying their evolution in Al–Mg–Zn alloys with < 1 wt.% Er and Zr, we find that the Al_3X dispersoid phase has a significant impact on the alloys' hardening characteristics. Detailed insights into the microstructure are obtained by a multi-scale analysis based on high-end transmission electron microscopy (TEM), atom-probe tomography (APT) and molecular dynamics (MD) simulations. A key for the rational design of multi-phase strengthened aluminum alloys lies in the spatial correlation between the dispersoids and the precipitate phase.

MM 4.2 Mon 10:30 IFW B

Analysis of the miscibility gap in Copper-Nickel with Atom Probe Tomography — •Rüya Duran and Guido Schmitz — University of Stuttgart, 70569 Stuttgart, Germany

Although Copper-Nickel alloys are commonly used in technical applications, their alloying behavior at low temperatures is still controversial. Early theoretical and indirect experimental investigations indicated that the phase diagram may contain a miscibility gap. Nevertheless, direct experimental proof is missing due to the slow kinetics at low temperatures.

In this project, the miscibility gap is determined by a direct experimental method applying Atom Probe Tomography (APT) to thin film structures. The temperature and time dependence of the segregation in Cu/Ni thin films is investigated. The quantitative evaluation was made by a cluster analysis, which determines the local atomic fraction in coarse-grained analysis cells located around each detected atom. By plotting the abundances of the concentrations (histograms), the boundary concentrations of a miscibility gap for a certain temperature are given.

At temperatures of total miscibility, the cluster analysis show deviations from binomial distribution, which can be explained by statistical fluctuations in concentration. By using a recently developed model based on the probability distribution of the local concentration, important thermodynamic parameters can be extracted, like the Gibbs free energy and the chemical potential, which also can be used to predict the critical temperature of the miscibility gap.

MM 4.3 Mon 10:45 IFW B

Investigation of irradiation damage in thin plates of Ti6Al4V via high-energy x-ray diffraction — •Tim Lengler[1,4], Dieter Lott[1], Peter Staron[1], Emad Maawad[1], Sabine Riemann[2], Andriy Ushakov[3], and Gudrid Moortgat-Pick[3,4] — [1]Institute of Material Research, Helmholtz-Zentrum Geesthacht, Germany — [2]Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany — [4]Universität Hamburg, Hamburg, Germany

In order to ensure stable long-term operation of the planned positron source for the International Linear Collider (ILC), candidate materials for the conversion target have to be tested. The intense electron beam at the Mainz Microtron (MAMI) injector was used for first irradiation tests on thin plates of Ti6Al4V which is a promising candidate material for the positron conversion target as well as for the exit window to the photon beam absorber. In this work, the beforehand at MAMI irradiated plates, simulating realistic irradiation impacts as expected at the ILC, were studied via high-energy synchrotron diffraction in transmission geometry at the P07 beamline at PETRA III to investigate the potential irradiation damage. Complementary, standard source x-ray diffraction measurements were carried out in reflection geometry to gain sensitivity for surface modifications. The synchrotron and x-ray studies allow us to investigate the microstructure in a non-destructive way and, in particular, to observe changes in the phase composition and the grain size distribution due to irradiation that may compromise the long-term stability of the material.

MM 4.4 Mon 11:00 IFW B

In situ X-radiography observations of thin binary metallic alloys to investigate pattern formation and growth characteristics — •Maike Becker[1], Jonathan A. Dantzig[2], Laszlo Sturz[3], Matthias Kolbe[1], and Florian Kargl[1] — [1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft-und Raumfahrt, 51170 Köln, Germany — [2]Department of Mechanical Science and Engineering, University of Illinois, Urbana, IL, 61801, USA — [3]Access e.V., Intzestr. 5, 52072 Aachen, Germany

X-radiography enables the observation of the solidification process in a few hundred microns thin samples of metallic alloys in real-time. The choice of thin samples avoids a superposition of the solidification structures and exploits the X-ray contrast through a clear distinction between the solid and liquid phases. Therefore, solidification characteristics like microstructure morphologies, growth velocities or concentration changes can be determined quantitatively. These data are used to better understand the influence of important material properties on microstructure formation. For example, the anisotropy of the solid-liquid interfacial energy plays an important role in the selection of growth directions and in the selection constant of the dendrite tip (and thus influences tip radius and growth velocities). The diffusion coefficient influences the formation of higher-order dendrite arms and the interaction distance between the crystals. In this context, the experimental data is used for comparison and validation of micro- and mesoscale simulations, like phase-field and dendrite needle network models.

MM 4.5 Mon 11:15 IFW B

Atomistic investigation of the elastocaloric effect in nanoporous NiTi structures — •Arne J. Klomp and Karsten Albe — Fachgebiet Materialmodellierung, Institut für Materialwissenschaft, Technische Universität Darmstadt, Germany

Shape memory or superelastic alloys exhibit strong elastocaloric response and can potentially be used in solid state cooling devices. The most promising material is NiTi due to the large latent heat released during the martensitic phase transition.

By constructing nanosized open porosity foams of NiTi one can in principle strongly increase the surface to volume ratio in order to improve the heat transfer between elastocaloric medium and heat transport medium. Using classical molecular dynamics simulations the thermomechanical properties and stability of NiTi nanofoams under cyclic mechanical loading is investigated.

Our work reveals that even in complex and random nanosized structures a martensic phase transition can be triggered by uniaxial compression and thus the elastocaloric effect can be exploited for cooling applications. We further show the impact of temperature on the amount of transformed phase, accumulated damage during cyclic loading, latent heat of the phase transformation and a possible coefficient of performance. Finally, the results give implications for limits of the maximum deformation as well as speed of deformation.