MM 4: Liquid and Amorphous Metals I

Time: Monday 11:00–13:00 Location: IFW D

MM 4.1 Mon 11:00 IFW D

Effects of rhenium on glass formation and mechanical properties of metastable ZrCuAl alloys — •Steffen Schmitz, Wolfgang Löser, Hansjörg Klauss, Christine Mickel, and Bernd Büchner — IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany

The effect of small additives of Re on a metallic glass forming alloy $(Cu_{46}Zr_{46}Al_8)_{100-x}Re_x$ (x = 1, 2) was investigated for samples of different sizes. Re possess a positive enthalpy of mixing within the Cu-Re terminal system. Splat quenched foils of ≈ 40 μm thickness display amorphous structure. Their crystallization temperature increases from $T_x = 500$ to 510 °C with increasing Re fraction at nearly constant glass formation temperature $T_g = 440$ °C. By contrast, injection cast rods consist of B2 - CuZr type metastable phase dendrites, a cubic CuZrAl type phase and randomly distributed small particles of a Re-rich phase. The presence of metastable phases leads to a unique combination of mechanical properties of as-cast rods which display high strength at sizeable plastic deformation up to $\epsilon_p \approx 4\,\%$ and an extended range of work hardening prior to failure.

MM 4.2 Mon 11:15 IFW D

Study of mechanical property and crystallization of a Zr-CoAl bulk metallic glass — •Jun Tan[1,2,3], Yue Zhang[1], Mihai Stoica[1], Norbert Mattern[1], Fusheng Pan[2], and Jürgen Eckert[1,3] — [1]IFW Dresden, Institute for Complex Materials, P.O. Box 27 01 16, D-01171 Dresden, Germany — [2]Materials Science & Engineering College, Chongqing University, 400030 Chongqing, China — [3]TU Dresden, Institute of Materials Science, D-01062 Dresden, Germany

The mechanical property of Zr56Co28Al16 bulk metallic glasses (BMGs) under compression test at room temperature was investigated. The alloy exhibited high fracture strength of approximately 2136 MPa and a pronounced plastic strain of 10.2%. No strainhardening behavior was observed. The evolution of the morphology of the shear bands on the lateral surface of the as-cast samples was studied using scanning electron microscopy (SEM). The plasticity can be attributed to the formation and interaction of multiple shear bands during deformation. The crystallization behavior was studied by differential scanning calorimetry (DSC) at different heating rates.The crystallization behavior research of this alloy indicates that the precipitation of the B2-ZrCo phase may be further utilized to promote the ductility of the ZrCoAl BMG composites.

MM 4.3 Mon 11:30 IFW D

Inhomogeneous deformartion of metallic glasses — •Stefan Küchemann, Dennis Bedorf, Walter Arnold, and Konrad Samwer — 1. Physikalisches Institut, Universität Göttingen, Germany

Despite recent progress it is still not clear how local rearrangements take place in bulk metallic glasses under external stress. Previous results show that homogeneous deformation can be separated into reversible and irreversible processes which can be interpreted in the potential energy landscape picture.[1]

In the experiments reported in this contribution, we investigated anelasticity in bulk metallic glasses with nominal composition $Pd_{40}Ni_{40}P_{20}$. To modify the potential energy state, structurally relaxed samples were deformed at room temperature. The stresses cover the range from elastic response to inhomogeneous flow. In DSC measurements we found that the heat flow below T_G showed a clear indication for a strain dependence. Thus a certain amount of energy could be stored and is thermally relaxed below T_G.

Financial support by the DFG SFB 602 and the Leibniz-Program is thankfully acknowledged.

[1] J. S. Harmon, M. D. Demetriou, W. L. Johnson, K. Samwer, Anelastic to Plastic Transition in Metallic Glass Forming-Liquids, Phys. Rev. Lett. 99, 135502 (2007)

MM 4.4 Mon 11:45 IFW D

Structure conserving correlation and the Kohlrausch-Williams-Watts relaxation in simulated metallic-glass forming Ni0.5Zr0.5 — •Helmar Teichler — Institut f. Materialphysik, Univ. Göttingen

In glass forming melts near the glass temperature, the alpha-decay reflects relaxation processes with Kohlrausch-Williams-Watts behaviour on macroscopic time scales. Microscopic explanation of these fundamental features is a challenging open question, which needs to understand emergence of slow relaxation with non-exponential response from atomic motions in the melt. Regarding this, we here present an analysis of molecular dynamics simulation results for glass forming Ni0.5Zr0.5. In detail it is shown that (a) the fraction of weakly effective particles (WEPs, in essence the immobile, vibrating atoms) determines the alpha-decay of the incoherent intermittent scattering function (ISF), (b) the WEPs exhibit strong temporal correlations in the way that particles acting as WEPs in an initial time window tend to act as WEPs also at later times, (c) this correlation makes that the alpha-process shows KWW-relaxation while uncorrelated change of particles between immobile and mobile behaviour yields Debye-relaxation.

MM 4.5 Mon 12:00 IFW D

Local mechanical spectroscopy on confined structures of metallic glasses — •Dennis Bedorf, Bo Zhang, Hannes Wagner, Moritz Schwabe, Walter Arnold, and Konrad Samwer — I. Physikalisches Institut, Universität Göttingen,Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Our aim is to investigate the local heterogeneity of glasses with an experimental approach. Up to now most of the knowledge about dynamical heterogeneities, like shear-transformation zones or string-like rearrangements, is based on computer studies. An atomic force based method which exploits contact-resonances of the cantilever, also called AFAM [1], enables us to study the elastic response and also anelastic losses on the nm-scale. Recent results have revealed a broad distribution of local moduli for amorphous PdCuSi on this length scale. Motivated by these findings we adopt this method to study size effects in glasses using nanoscaled samples prepared by lithography. First results indicate a significant softening for smaller samples.

[1] M. Kopycinska-Müller, and W. Arnold et al, Z. Phys. Chem. 222, 471 (2008)

MM 4.6 Mon 12:15 IFW D

Microstructure and magnetic properties of Gd-Hf-Co-Al glassy alloys by liquid-liquid phase separation — •Junhee Han[1,2], Norbert Mattern[1], and Jürgen Eckert[1,2] — [1]IFW Dresden, Institute for Complex Materials, Dresden, Germany — [2]TU Dresden, Institute of Materials Science, Dresden, Germany

Phase separated glassy ribbons were prepared in the Gd-Hf-Co-Al system by rapid quenching of the melt. From the Gd55Co25Al20 ternary good glass former, we substitute Gd with Hf by 10, 20, 27.5, 35, 45 and 55 at. %. Due to the strong positive enthalpy of mixing between the principal elements Gd and Hf (ΔHmix = +11kJ/mole) a heterogeneous microstructure is formed consisting of two amorphous phases Gd-enriched and Hf-enriched. For the alloys with clearly phase separated microstructure, nano-meter scale (~100nm) secondary phase separation is observed in each amorphous phase. In the case of the Gd27.5Hf27.5Co25Al20 alloy, coexistence of two different types of microstructure such as a droplet-like and interconnected structure were observed from the areas having different cooling rate. This microstructure evolution is in good agreement with calculation results by Lattice Boltzmann method. On the other hand, measured magnetic properties show the composition and volume fraction dependence of magnetization and transition temperature (Tc) of Gd-Hf-Co-Al system. The saturation magnetization decreases as a function of Hf contents and can be described by a simple mixture model.

[1] A. J. Wagner and J. M. Yeomans, Phys. Rev. Lett., 80 (1998) 1429

MM 4.7 Mon 12:30 IFW D

Influence of initial temperature and cooling rate on the liquid and amorphous structure of Cu47.5Zr47.5Al5 alloy simulated by molecular dynamics — •Valentin Kokotin and Jürgen Eckert — IFW Dresden, Institute for Complex Materials, Postfach 27 01 16, D-01171 Dresden, Germany

Atomic structure in liquid and supercooled/amorphous states has been investigated for the model alloy, Cu47.5Zr47.5Al5, with the help of classical molecular dynamics computer simulations. By rapid quench-

ing from the melt (used initial temperatures: 1200 and 2000 K) at various cooling rates (comprising 6 orders of magnitude), differently relaxed amorphous structures have been prepared. The cooling rate affects the structural and thermodynamic properties significantly. Density and fraction of icosahedra depend exponentially on the cooling rate. The initial temperature of the liquid has rather a tangential influence on the final amorphous structure. The major differences in supercooled structure arise at temperatures below 900K (undercooling of about 300K), where nearly amorphous structure is "born".

MM 4.8 Mon 12:45 IFW D

Magnetocaloric effect of $Fe_{86-x}B_{14}Nb_x$ metallic glasses — •Anja Waske, Björn Schwarz, Norbert Mattern, and Jürgen Eckert — Institut für Festkörper- und Werkstoffforschung (IFW), Dresden

Materials exhibiting the magneto-caloric effect could one day be the basis of a new magnetic cooling concept for consumer use, replacing conventional refrigeration technology. However, currently known materials with high magnetic entropy changes are very expensive and can hence not be applied on mass production scale. Here, we report on the magneto-caloric effect in comparatively cheap Fe-based metallic glasses. Glassy $Fe_{86-x}B_{14}Nb_x$ ribbons were prepared by rapidly quenching the liquid using the melt spinning technique. By diluting the magnetic lattice with Nb dopants, the Curie temperature decreases and, at highest Nb content, approaches room temperature. However, this effect is accompanied by a decrease of the saturation magnetization. From temperature dependent magnetization measurements the magnetic entropy change was calculated using the thermodynamic Maxwell equations. We will present the experimental results as a function of Nb content and discuss the applicability of the material for cooling purposes.