MM 65: Liquid & Amorphous Metals II

Time: Thursday 17:15–19:00 Location: H26

MM 65.1 Thu 17:15 H26

Study of crystallization behavior during ultrafast heating of metallic glasses — •Stefan Küchemann[1], Jonas Rübsam[1], Carsten Mahn[1], Goodwin Gibbins[4], Norbert Mattern[3], Marios Demetriou[2], William Johnson[2], and Konrad Samwer[1] — [1]1. Physikalisches Institut, Georg-August-Universität Göttingen, 37077 Göttingen, Germany — [2]Keck Laboratories of Engineering, California Institute of Technology, Pasadena, CA 91125, USA — [3]Leibniz Institut für Festkörper- und Werkstoffprüfung Dresden, 01171 Dresden, Germany — [4]University of Cambridge, Cambridge, UK

In this contribution, metallic glasses have been heated up homogeneously using a rapid capacitor discharge technique [1]. The heating rates of this technique are typically in the order of 10^6 K/s which allow experimental studies prior to the crystallization for temperatures up to the melting temperature or even suppress the crystallization completely.

In order to study the crystallization behavior of varios Zr-based glass formers, hard X-ray diffraction experiments have been performed at P07 beamline at DESY. To resolve short-time structural changes, the temporal resolution of the 2D Detector could be successfully increased up to 5 ms response time by using a newly developed chopper system.

For the metallic glass $Zr_{65}Cu_{27.5}Al_{7.5}$, the results show interesting features in the liquid state prior to the final crystalline stable phase.

Financial support by DFG within SFB 602 is gratefully acknowledged.

[1] William L. Johnson et al., Science 332, 828 (2011)

MM 65.2 Thu 17:30 H26

Decoupling of component diffusivities in glass-forming Zr-Ni-Ti-Cu-Be alloys above the melting temperature — •Sri Wahyuni Basuki[1], Fan Yang[2], Andreas Meyer[2], Klaus Rätzke[1], and Franz Faupel[1] — [1]Faculty of Engineering, Kiel, Germany — [2]Inst. of Materials Physics in Space, Köln, Germany

Previous work[1] on glass forming Pd-Cu-Ni-P alloys, showed that while a vast decoupling occurs between the diffusivity of Pd and of the smaller components, the diffusivities of all components merge close to the critical temperature T_c of mode coupling theory. For Pd, the Stokes-Einstein relation holds in the whole range investigated encompassing more than 14 orders of magnitude. In order to check for the general validity of these results, we extended our investigations to the Zr-Cu-Ni-Ti-Be system. In this work, Co-57 and Zr-95 tracer diffusivities were determined in glass-forming $Zr_{46.75}Ti_{8.25}Cu_{7.5}Ni_{10}Be_{27.5}$ above the melting temperature. In particular, measurements were carried out simultaneously to minimize artefacts from diffusion barriers and to reduce absolute errors. Even at 20 K above the liquidus temperature, the diffusivities of Zr and Co differ clearly by a factor of four, while Co tracer diffusivities agree very well with diffusivities determined by quasielastic neutron scattering. This together with measurements of the time dependence of the penetration profiles demonstrates the general reliability of the measurements. The results are discussed in connection with viscosity data and the Stokes-Einstein equation in terms of imperfect equilibration of the melt.

[1] A. Bartsch et al., Phys. Rev. Lett. 104, 195901 (2010).

MM 65.3 Thu 17:45 H26

Diffusion and relaxation in a HPT-deformed Zr-based bulk metallic glass — •Jonas Bünz[1], Koichi Tsuchiya[2], Sergiy Divinsky[1], and Gerhard Wilde[1] — [1]Institut für Materialphysik, WWU Münster — [2]National Institute for Materials Science, University of Tsukuba

Metallic glasses are still an attractive object of investigation in the field of materials physics due to their outstanding mechanical properties. Hardness and yield strength exceed the values of their crystalline counterpart by far, but the applicability of metallic glasses is limited by the lack of considerable plasticity. Stress localization and the associated shear softening strongly weaken the structure, thus leading to the formation of shear bands. The structure of shear bands is still far from being understood. Due to their extreme sensitiveness to the free volume localization, the diffusion measurements by the radiotracer technique can bring further insight into the structural modifications of shear bands with respect to the amorphous matrix as well as to the conditions of slip during plastic straining. Here, we present the results of diffusion as well as relaxation experiments in HPT-deformed Zr-based bulk metallic glass.

MM 65.4 Thu 18:00 H26

Ultrastable Metallic Glass — •Hai-Bin Yu, Yuansu Luo, and Konrad Samwer — I. Physikalisches Institut, Universität Göttingen, Germany

Recently, some novel organic glassy materials, termed *ultrastable glasses* that exhibit remarkable thermodynamic and kinetic stabilities have been prepared by deposition techniques. These ultrastable glasses are at the low energy state on the potential energy landscape, unreachable by quenched glasses that aged for long-time. These materials are of special interest for understanding many fundamental issues regarding the nature of glasses. In this work, we prepared a series of free-standing Zr65Cu27.5Al7.5 metallic glass foils by magnetron sputtering with a very low deposition rate at different substrate temperatures. The resultant materials are homogenously amorphous and have a remarkable higher glass transition temperature Tg than a quenched glass made of the same composition. They are a kind of ultrastable metallic glass. An interesting finding is the ultrastable metallic glass can be prepared only within a narrow substrate-temperature range, from 0.7 to 0.8 Tg of the quenched glass. Above this temperature range the Tg of the deposited glass even decreases. This suggests a signature of surface enhanced relaxation dynamics, a topic currently actively discussed in glassy physics. Structural analysis shows the ultrastable metallic glasses have unique fractural-like nanostructures. H.B. Yu thanks the Alexander von Humboldt Foundation. We acknowledge support from the DFG via the SFB 602 and the Leibniz Program.

MM 65.5 Thu 18:15 H26

Atomic structure and glass-forming ability of Ni64Zr36 and Cu65Zr35 alloys — •Ivan Kaban[1,2], Pal Jovari[3], Valentin Kokotin[4], Olga Shuleshova[2], Brigitte Beuneu[5], Karel Saksl[6], Norbert Mattern[2], Jürgen Eckert[1,2], and Lindsay Greer[7] — [1]TU Dresden, Institute of Materials Science, Germany — [2]IFW Dresden, Institute for Complex Materials, Germany — [3]Institute for Solid State Physics and Optics, Budapest, Hungary — [4]Access e.V., Aachen, Germany — [5]Laboratoire Leon Brillouin, CEA-Saclay, France — [6]Institute of Materials Research, Kosice, Slovak Republic — [7]Department of Materials Science and Metallurgy, University of Cambridge, UK

Atomic structure of Ni64Zr36 and Cu65Zr35 alloys in glassy and crystalline states has been investigated by different experimental techniques (X-ray diffraction, neutron diffraction with isotopic substitution, extended X-ray absorption spectroscopy) and theoretical methods (reverse Monte-Carlo simulation, molecular dynamics modelling, Voronoi analysis) to explain the differences in the glass-forming abilities of these two compositions. It is established that the Ni64Zr36 glass is characterized by pronounced topological and chemical ordering, while the Cu65Zr35 glass is topologically ordered and chemically rather disordered. Remarkably large differences in the partial pair distribution functions for the Cu65Zr35 alloy in glassy and crystalline states are suggested to play a decisive role in increasing its bulk-glass-forming ability.

MM 65.6 Thu 18:30 H26

Structure formation in binary amorphous Al alloys with early transition metals from the 4th, 5th, and 6th period — •Martin Stiehler[1], Danny Müller[2], Michael Pleul[1], and Peter Häussler[1] — [1]Chemnitz University of Technology, 09107 Chemnitz, Germany — [2]now at Roth & Rau AG, 09337 Hohenstein-Ernstthal, Germany

Amorphous phases as precursors of the crystalline state are indispensable model systems to study fundamental structure forming processes and the related evolution of electronic transport. During the last years we were able to show that many different classes of alloys organize themselves under the influence of a resonance between the global subsystems of the electrons on the one hand and the static structure on the other hand. Especially for binary Al-TM alloys (TM: the transition metals of the 4th period Sc,Ti,V,Cr,Mn,Fe,Co,Ni,Cu) we already reported on an electronic influence on phase stability involving hybridization effects between the Al-p- and the TM-d-states.

In this contribution we report on an extension of these investigations to systems with transition metals of the 5th and 6th period. Especially, we will present results on structural and electronic properties of the binary systems Al-(Sc,Y,La,Ce) in the amorphous state. Although the four systems contain early transition metals from three different periods of the periodic table, they exhibit very similar properties, seemingly related to a mean valency of 1,5e/a in terms of the resonance model.

MM 65.7 Thu 18:45 H26

On structural and electronic properties of Al-Pd Alloys — •Pierre Pudwell, Nan Jiang, and Peter Häussler — Chemnitz University of Technology, Institute of Physics, 09107 Chemnitz

In recent years we reported on an electronic influence on phase stability of Al-3d-TM alloys (TM: Sc, ..., Cu). The electronic influence is based on an internal exchange of momentum between global subsystems, namely the electronic system and the forming static structure. Both systems come into resonance to each other. The resonance is enhanced by hybridization effects between Al-p- and TM-d-states. Structure formation, phase stability and the evolution of electronic transport properties were found to be strongly related. In order to test whether such a hybridization enhanced resonance is also effective in other systems, we are about to extend our investigations to systems with 4d- and 5d-TM.

In our contribution we show data on Al-Pd alloys as representative for a system with 4d-TM. Thin films of the material were deposited in-situ at about 4K, the resistivity was measured during annealing from 4K to several hundred K, the static atomic structure after annealing to 350K. By comparing the diameter of the strongest diffraction ring with the diameter of the Fermi-sphere, stabilizing resonances were detected, indicating regions with different structural and electronic properties. Between 30 and 70 at.% Pd, there seems to be a hybridization effect like in the Al-3d-TM sytems. For higher and lower Pd concentrations a resonance effect without hybridization seems to dominate – comparable to simple amorphous alloys without transition metals.