MM 69: Topical session: Dynamics, relaxation and deformation in deeply supercooled metallic liquids and glasses VII - thermodynamics and structure

Time: Thursday 17:30–19:00 Location: IFW A

MM 69.1 Thu 17:30 IFW A

Vibrating-reed mechanical spectroscopy of an electrodeposited Ni-P nanoglass — •Hans-Rainer Sinning[1], Yulia Ivanisenko[2], Tao Feng[3], Di Wang[2], Herbert Gleiter[2,3], and Horst Hahn[2,3] — [1]Institut für Werkstoffe, Technische Universität Braunschweig, Germany — [2]Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany — [3]Herbert Gleiter Institute of Nanoscience, Nanjing University of Science and Technology, China

A nanoglass with a composition near $Ni_{83}P_{17}$ consisting of nanometer-sized amorphous "grains" and amorphous interfaces between these grains was prepared by a multi-phase pulse electrodeposition technique. As-deposited films were cut into 1mm x 10mm stripes and studied by mechanical spectroscopy at frequencies between 0.1 and 3 kHz using the vibrating-reed technique. Temperature-dependent spectra of internal friction and elastic stiffness were measured between 100 and 800 K. A thermally activated relaxation peak was observed above 400 K, followed by some irreversible transformation around 500 K after which the relaxation peak disappears. This transformation prevents an accurate determination of the activation parameters, which can only roughly be estimated to be of the order of 1 eV and 10^{13} s^{-1}. The relaxation may be discussed from different viewpoints either as a type of beta relaxation, or as an interface relaxation somehow analogous to grain boundary relaxation in polycrystals. A final crystallization effect was found in both elastic modulus and internal friction at 750 K, which is 150 K higher than the crystallization of a conventional, melt-spun Ni-P metallic glass.

MM 69.2 Thu 17:45 IFW A

Cryogenic Rejuvenation of Metallic Glasses — •Jonas Lübke, Isabelle Binkowski, Niklas Nollmann, Martin Peterlechner, Harald Rösner, and Gerhard Wilde — Institute of Materials Physics, WWU Münster, Germany

The material class of metallic glasses shows interesting properties such as high strength, toughness and corrosion resistance. However, a severe lack of ductility makes the material unsuitable for many applications. In the past, a lot of work was concentrated on reducing this disadvantage using micro-alloying or crystalline precipitates with notable success. A different approach is the concept of "free volume" in metallic glasses. The redistribution of present free volume may lead to enhanced ductility. This so called rejuvenation can be achieved by mechanical preloading in the elastic regime. Ketov et al. [1] claim to achieve this rejuvenation by using the heterogeneous thermal expansion coefficient of metallic glasses to induce internal strain by thermal cycling. To avoid structural relaxation these cycles have to be at cryogenic temperatures. By this the ductility of the metallic glass is said to be improved in a different and simple way. In this contribution effects of different degrees of cryogenic rejuvenation, i.e. change in cycle numbers and resting times at different temperatures, on the metallic glasses Vitreloy1, $Pd_{40}Ni_{40}P_{20}$ and $Pd_{39}Ni_{41}P_{20}$ on their amount of free-volume, structural relaxation and mechanical properties are presented and discussed.

[1] S. V. Ketov et al. Rejuvenation of metallic glasses by non-affine thermal strain. Nature 524, 2015

MM 69.3 Thu 18:00 IFW A

Effect of Co microalloying on the low-temperature heat capacity of $Pd_{40}Ni_{40}P_{20}$ bulk metallic glass — •Rene Hubek[1], Mikhail Seleznev[2], Isabelle Binkowski[1], Martin Peterlechner[1], Sergiy Divinski[1], and Gerhard Wilde[1] — [1]Institute of Materials Physics, University of Münster, Germany — [2]Togliatty State University, Togliatty, Russia

The physical properties of bulk metallic glasses are a subject of intensive research especially with respect to their mechanical behavior. Recently it was shown that the mechanical properties of a model $Pd_{40}Ni_{40}P_{20}$ bulk metallic glass could significantly be enhanced through cobalt microalloying [1]. The present study is focused on the impact of the microalloying on the low-temperature heat capacity. The results are discussed in comparison to the heat capacity data of a reference $Pd_{40}Ni_{40}P_{20}$ glass, specifically concerning the impact of microalloying on the excess heat capacity at low temperatures that is known as "boson peak" and concerning its specific response on plastic deformation [2]. An additional magnetic heat capacity anomaly is observed in the low temperature region of Co-alloyed $Pd_{40}Ni_{40}P_{20}$ glass. The effect of annealing on low-temperature heat capacities of as-cast and cold-rolled glasses is carefully analyzed.

[1] N. Nollmann et al., Scripta Marerialia 111 (2016), 119-122
[2] Yu. Mitrofanov et al., Phys. Review Letters 112 (2014)

MM 69.4 Thu 18:15 IFW A

Characterization of the Fe67Mo6Ni3.5Cr3.5P12C5.5B2.5 bulk metallic glass forming alloy — •Benedikt Bochtler, Oliver Gross, Isabella Gallino, and Ralf Busch — Saarland University, Chair of Metallic Materials, Campus C6.3, 66123 Saarbrücken, Germany

The bulk metallic glass steel Fe67Mo6Ni3.5Cr3.5P12C5.5B2.5 is characterized in detail to evaluate its general applicability [1]. This alloy was designed by Johnson et al. [2] and provides a high critical casting thickness of 13 mm. For the casting of amorphous parts, as well as the processing via thermoplastic forming, thermodynamics and viscosity of an alloy are crucial. The thermophysical properties, including the specific heat capacity, were measured using calorimetric methods. The crystallization behavior of amorphous samples upon heating was characterized by DSC and XRD and a TTT diagram was constructed. The equilibrium viscosity below the glass transition as well as volume relaxation behavior were measured by three-point beam bending and dilatometry, to assess the kinetic fragility. Viscosity in the liquid state was determined, using electromagnetic levitation in microgravity on a reduced gravity aircraft. The alloy displays a strong liquid behavior at low temperatures and a fragile behavior at high temperatures. These results are analog to the ones observed in several Zr-based bulk metallic glass forming liquids [3], indicating a strong to fragile liquid-liquid transition. Ref.: [1] B. Bochtler, et al., Acta Materialia, 118: 129-139, (2016) [2] J.H. Na, et al., US Patent App. 14/335,163; #20150020929 A1, (2015) [3] S. Wei, et al., Nature Comm, 4: 2083, (2013)

MM 69.5 Thu 18:30 IFW A

Thermodynamic and dynamic studies of phosphorus containing bulk glass forming liquids — •Oliver Gross, Benedikt Bochtler, Moritz Stolpe, Simon Hechler, William Hembree, Ralf Busch, and Isabella Gallino — Saarland University, Chair of Metallic Materials, Campus C6.3 66123 Saarbruecken, Germany

Phosphorous containing bulk metallic glass forming alloys (BMGs) are among the best metallic glass formers known to date. The newly developed Ni-P-based BMGs are no exception (critical casting thickness *1 cm) and provide an attractive alternative to Zr-based BMGs for industrial applications due to their relatively inexpensive constituents, good processability and exceptional corrosion resistance. Pt-P-based BMGs feature a large supercooled liquid region and an attractive color, which makes them highly promising for jewelry applications.

In this comparative study, the thermophysical properties of different phosphorus containing alloys (Ni-P, Pt-P) are investigated using differential-scanning calorimetry and thermal mechanical analysis for the determination of the specific heat capacity and equilibrium viscosity, respectively. The specific heat capacity data was used to calculate the enthalpy and entropy difference between the liquid and the crystalline mixture. Interestingly, the alloys differ considerably in their thermodynamic properties, whereas they show a similar behavior in the temperature dependence of their equilibrium viscosity.

MM 69.6 Thu 18:45 IFW A

Thermodynamic and kinetic properties as well as low temperature relaxations of Mg-based bulk metallic glasses — •Maximilian Frey, Ralf Busch, and Isabella Gallino — Chair of Metallic Materials, Saarland University

A broad set of thermodynamic and kinetic properties of four Mg-based metallic glass forming systems was established using calorimetric studies, thermophysical analysis, as well as thermomechanical analysis. Beside considerations about the fragilities of these alloys, especially the appearance of a secondary relaxation event occuring at temperatures distinctly below the glass transition was analysed via modulated DSC scans and isochronal DMA measurements. The definition

of the Johari-Goldstein-type secondary relaxation as a general feature of metallic glasses has become increasingly popular in recent literature. However, the present relaxation signals exhibit characteristics, which are atypical for this kind of secondary event, like e.g. relatively high activation energies of about 135 kJ/g-atom. In combination and consistency with other works also investigating a Mg-based alloy via DMA and XPCS, a model is presented that explains the secondary relaxation event through a broad structural relaxation time spectrum. In this light, the corresponding measurement signals are interpreted as the premature thawing of defect regions, which exhibit increased free volume and are embedded in the surrounding more densely packed glassy backbone.