MM 41: Liquid and Amorphous Metals

Thermodynamics and Kinetics

Time: Wednesday 15:15–16:45 Location: TC 010

MM 41.1 Wed 15:15 TC 010

Development and Characterization of Sulfur-bearing Bulk Metallic Glasses — •Alexander Kuball, Oliver Gross, Benedikt Bochtler, and Ralf Busch — Saarland University, Saarbrücken, Germany

Bulk metallic glass formation can be observed in many metallic systems by rapid cooling from the equilibrium liquid. However, the best metallic glass formers known so far can be found in systems with high concentrations of expensive and/or toxic elements like zirconium, phosphorous, or beryllium, limiting their commercialization.

Recently, we reported on a completely novel family of sulfur-bearing bulk metallic glasses (BMGs) excluding toxic elements. Bulk glass formation is observed in several multicomponent systems like in Pd-, Zr-, Cu-, Ni- and Ti-based alloys. Among these systems, especially the novel Ti-based alloys are of great interest for many fields of application. They show casting thicknesses for the synthesis of fully amorphous samples of up to 1 mm in combination with record Ti-contents of up to 70 at%, yielding to enormously high specific strength values.

The process of glass formation in these novel systems is discussed in terms of kinetics and thermodynamics. Because of the compositional differences in comparison to the BMG forming liquids known so far, the thermophysical characterization of sulfur-bearing BMGs may lead to an extended understanding of the glass forming ability in metallic systems in general.

MM 41.2 Wed 15:30 TC 010

Effect of Co microalloying on thermodynamic properties of a Pd40Ni40P20 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 subject of intensive research especially with respect to their mechanical behavior. Recently, it was shown that the mechanical properties of a Pd40Ni40P20 bulk metallic glass could significantly be enhanced through cobalt microalloying [1]. In this report we are focusing on the low-temperature hear capacity and DSC measurements. The results are discussed in comparison to the reference Pd40Ni40P20 glass [2, 3]. The effect of plastic deformation and post-deformation annealing on the excess heat capacity at low temperatures, known as the *boson peak*, is thoroughly examined. For DSC measurements the relaxation behavior of the fictive temperature and the overshoot enthalpy is investigated.

These data are discussed with respect to the excess free volume distribution in the PdNiP glass and the impact of Co microalloying.

[1] N. Nollmann et al., Scripta Marerialia 111 (2016), 119-122
[2] Y.P. Mitrofanov et al, Acta Materialia 90 (2015) 318-329.
[3] I. Binkowski et al, Acta Materialia 109 (2016) 330-340.

MM 41.3 Wed 15:45 TC 010

On the high glass-forming ability of Pt-Cu-Ni/Co-P-based liquids — •Oiver Gross, Sascha S. Riegler, Moritz Stolpe, Benedikt Bochtler, Alexander Kuball, Ralf Busch, and Isabella Gallino — Chair of Metallic Materials, Saarland University, Campus C6.3, 66123 Saarbrücken, Germany

Continuous and isothermal crystallization diagrams of the Pt42.5Cu27Ni9.5P21 and the Pt60Cu16Co2P22 bulk glass forming compositions are determined using calorimetric experiments. For the Pt42.5Cu27Ni9.5P21 liquid, the formation of the primary crystalline phase can be prevented by rapid cooling in a conventional DSC. In contrast, for similar cooling conditions, the formation of the primary precipitating compound in Pt60Cu16Co2P22 cannot be prevented in a conventional DSC as also observed in in-situ synchrotron X-ray scattering experiments. This is attributed to a critical overheating, above which remaining structures dissolve, resulting in a drastic increase of the degree of undercooling, similar to what is observed in Zr-based BMGs. Using the classical nucleation theory, the combined thermodynamic and kinetic data are used to model the isothermal crystallization data for Pt42.5Cu27Ni9.5P21, yielding an interfacial energy value of 0.11 J/m2 between the primary nucleating crystal and the liquid. This value is three times higher than the value for good Zr-based glass-formers, suggesting that the interfacial energy plays a pivotal role in the exceptionally high glass-forming ability of Pt-P-based systems and compensates for the fragile liquid behavior and the large driving force for crystallization.

MM 41.4 Wed 16:00 TC 010

The role of the Ga addition to the thermodynamics, kinetics, and tarnishing properties of the Au-Pd-Cu-Ag-Si bulk metallic glass forming system — •Nico Neuber[1], Oliver Gross[1], Miriam Eisenbart[2], Ulrich Klotz[2], Isabella Gallino[1], and Ralf Busch[1] — [1]Chair of Metallic Materials, Saarland University, Campus C6.3, 66123 Saarbrücken, Germany — [2]FEM, Research Institute for Precious Metals & Metals Chemistry, Katharinenstrasse 17, 73525 Schwäbisch Gmünd, Germany

In the last decade, the 18-karat gold Au-Ag-Pd-Cu-Si bulk metallic glass (BMG) system has received considerable attention as jewelry material due to its extraordinary premium-white gold color, the absence of allergen constituents such as Ni, Cr, and Co, twice the hardness of cold worked or age hardened conventional white gold alloys, melting temperatures below 700 K, less than 0.5% solidification shrinkage and a good processing ability. However, this system is affected by non-uniform tarnishing that is detrimental to its application. This behaviour is typical for a mixture of elements with very different nobility, where preferential oxidation and partitioning are common processes observed upon reaction with the environment. Based on thermodynamic considerations we have judiciously added Ga to the aforementioned system and developed novel 18-karat premium-white gold BMG compositions with improved tarnishing resistance. We report here upon the strategy applied to develop the novel compositions and the influence of the added Ga on the thermodynamics and kinetics of the system is assessed and possible further solutions are reviewed.

MM 41.5 Wed 16:15 TC 010

Synthesis and characterization of Tb75Fe25 nanoglass — •Shiv Prakash Singh, Herbert Gleiter, and Horst Hahn — Institute of Nanotechnology, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany

Nanoglasses have been developed with the original idea to generate a new kind of amorphous material, by the controlled introduction of defects and alterations of the chemical microstructure. This approach is similar to that used in nanocrystalline materials. In this work, we have synthesized a Tb75Fe25 nanoglass using the inert gas condensation method, by compaction of nanometer sized Tb75Fe25 glassy particles at 3 GPa. The as prepared nanoglass specimen (NG) was subjected to high pressure torsion (HPT) at 6 GPa with three complete rotations. X-ray diffraction pattern for the NG and the nanoglass specimen prepared using HPT (NGT) demonstrate the amorphous nature. Transmission electron microscopy revealed the amorphous structure with a small fraction of a crystalline phase for both NG and NGT. Differential scanning calorimetry demonstrated a lower crystallization temperature for the NGT in comparison to the NG. The NG showed a higher coercivity and lower magnetization than the NGT at 1.8K. The above NG and NGT specimens have then been heat treated at 390 oC for 30 minutes. The coercivity decreased for both heat treated samples compared to NG and NGT due to evolution of iron reach crystalline phase (Fe2Tb).

MM 41.6 Wed 16:30 TC 010

Low temperature excess heat capacity of AlYFe metallic glasses — •Marius Gerlitz, René Hubek, Martin Peterlechner, Harald Rösner, and Gerhard Wilde — Institute of Materials Physics, University of Münster

The deformation behavior of metallic glasses differs from their crystalline counterpart due to the absence of defects like dislocations. Metallic glasses deform at ambient temperatures typically by nanometer sized, localized shear bands. To what extend a change in the structure of the surrounding matrix contributes to the plastic deformation is under current investigation. The vibrational states of atoms depend on their bonding and consequently on their mechanical coupling.

Thus, low temperature specific heat measurements are well suited to understand fundamental characteristics of vibrational modes. The excessive contribution to the specific heat at low temperatures, known as the boson peak, is a distinct feature in glasses and is though as being closely related to the structural states that allow for unit shear events. This work focuses on AlYFe as a representative of marginally glass forming systems. Deformed and relaxed sample states were analyzed by heat capacity measurements, X-ray-diffraction, calorimetric measurements as well as electron microscopy. The results are discussed with respect to the present literature on the boson peak. An enhanced relaxation behavior of metallic glasses is observed in deformed samples. The matrix is stated to be involved in the relaxation process.