MM 22: Liquid and Amorphous Metals - Metallic Glass

Time: Tuesday 10:15–11:30 Location: IFW D

MM 22.1 Tue 10:15 IFW D

Effect of Co micro-alloying on thermodynamic and kinetic properties of a $Pd_{40}Ni_{40}P_{20}$ bulk metallic glass — •Rene Hubek, Isabelle Binkowski, Martin Peterlechner, Sergiy Divisinki, and Gerhard Wilde — Institute of Materials Physics, University of Münster, Germany

The physical properties of bulk metallic glasses are subject of intense research especially with respect to their mechanical behavior. Recently, it was shown that the mechanical properties of a $Pd_{40}Ni_{40}P_{20}$ bulk metallic glass could significantly be enhanced through cobalt micro-alloying [1]. In this report, we are focusing on the low-temperature heat capacity and shear band diffusion measurements. The results are discussed in comparison to the reference Co-free Pd40Ni40P20 glass [2, 3]. The response of the excess heat capacity at low temperatures, known as the boson peak, on plastic deformation and post-deformation annealing is thoroughly examined. Furthermore, the influence of annealing and micro-alloying on the shear band diffusion is investigated. These data are discussed with respect to the relaxation behavior. The correlated study of thermodynamic and kinetic properties of deformed glasses provides further insights into origin of plasticity enhancement by Co-micro-alloying of PdNiP-glass.

[1] N. Nollmann et al., Scripta Materialia 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 22.2 Tue 10:30 IFW D

Effects of pretreatments on the mechanical properties of metallic glasses — •Hongbo Zhou[1], Yuriy Mitrofanov[2], and Gerhard Wilde[1] — [1]Institute of Materials Physics, University of Muenster, Wilhelm-Klemm Strasse 10, Muenster 48149, Germany — [2]Department of General Physics, State Pedagogical University, Lenin Street 86, Voronezh 394043, Russia

Pretreatments including annealing and plastic deformation have a significant influence on the microstructure and non-equilibrium state of metallic glasses such as medium range order and the rejuvenation behavior. Therefore, connecting these influences to the resulting mechanical properties seems very promising to help understanding some basic issues, such as the structural origin of plasticity, heat effects and shear modulus softening. In this work, the samples were pretreated by low-temperature annealing, high-pressure torsion and cold rolling. The energetical state and thermal properties of metallic glasses were evaluated by differential scanning calorimetry and a physical property measurement system. Three-point bending, compression and shear modulus tests were carried out. The relation between mechanical properties and thermal properties was discussed. In addition, the differential scanning calorimetry curve can be reconstructed with the shear modulus data within the framework of the interstitialcy theory, which demonstrates the similar structural origins of the heat effect and shear modulus softening in metallic glasses.

MM 22.3 Tue 10:45 IFW D

Investigation of creep in Pd40Ni40P20 metallic glasses — •Christian Aaron Rigoni, Sergiy Divinski, and Gerhard Wilde — Institute of Materials Physics, Münster, Germany

Metallic glasses are well known for their distinguished mechanical properties like high hardness and tensile strength, but marginal - if any - ductility. Therefore, long-time behaviour of metallic glasses under creep conditions is important for an optimal application of the material in order to prevent unexpected failures. In contrast to crystalline materials, where the creep mechanisms are well understood in terms of evolution of lattice defects, these mechanisms are still not well known for metallic glasses especially at temperatures far below Tg, where plastic deformation occurs through shear banding effecting local areas (shear transformation zones). Pd40Ni40P20 is chosen as a model metallic glass due to its high thermal stability over a wide temperature range and superior glass forming abilities. Even though Pd40Ni40P20 is a good glass former, the casted bulk samples are limited to certain sample dimensions, which makes classical tensile testing machines useless for this application. In our case the measurements are proceeded in a miniaturized tensile testing machine, which uses a sample length of about 4 mm with a gauge section of about 0.3 mm2. The first results on creep behaviour at temperatures 400 to 470 K (more than 100 K below Tg) are presented and discussed.

MM 22.4 Tue 11:00 IFW D

Impact of cryogenic cycling on plastically deformed Pd40 Ni40 P20 bulk metallic glass as studied by tracer diffusion measurements — •Afrouz Hassanpour, Sergiy Divinski, and Gerhard Wilde — Institute of Materials Physics University of Münster Wilhelm-Klemm-Str. 10 48149 Münster Germany

Rejuvenation via cryogenic cycling is an intensively investigated, but still obscure phenomenon for bulk metallic glasses. The calorimetric response of cryo-cycled as-cast and relaxation-annealed PdNiP glasses was found to remain practically unchanged. In the present work, tracer diffusion is used as a probe of structural changes induced by cryo-cycling in PdNiP glasses plastically deformed by high-pressure torsion and cold rolling. The penetration profiles for 57Co atoms reveal specific changes when samples were subjected to cryogenic cycling including both volume and short-circuit (shear band) diffusion contributions. The results substantiate a distinct impact of the cryogenic thermocycling on shear transformation zones and shear band structures, with the latter being characterized by significantly enhanced diffusion coefficients. Thus, the shear bands reveal a kind of kinetic rejuvenation induced by cryo-cycling and apparently a higher susceptibilitay for structural modifications through cryo-cycling as compared with undeformed material, at least for the model PdNiP glass.

MM 22.5 Tue 11:15 IFW D

Effect of Gd micro-alloying on thermodynamic, kinetic and mechanical properties of a Pd40Ni40P20 bulk metallic glass — •Saba Khademorezaian[1], Martin Peterlechner[1], Marilena Tomut[2], and Gerhard Wilde[1] — [1]Westfälliche Wilhelms-Universität Münster, Münster, Germany — [2]GSI Helmholtzzentrum für schwerionenforschung, Darmstadt, Germany

In the field of bulk metallic glasses, minor additions have proven to be a powerful tool to enhance different properties, among which glass forming ability, thermal stability and plasticity are forming the focus of this report.

We have studied the impact of adding 1 at% Gd to a reference Pd40Ni40P20 bulk metallic glass on glass forming ability, crystallization kinetics and also fictive glass transition temperature. [1] As Nollmann et al. [2] shown, minor addition of different elements can have a positive or negative impact on the mechanical properties of metallic glasses. The impact of the Gd addition on the glass forming ability was performed by calorimetric analyses and mechanical properties were investigated by compression test as well as by micro- and nano-indentation. Studying the changes in glass plasticity caused by different alloying additions can also provide better knowledge of deformation mechanism, shear band formation and propagation. [3]

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