MM 4: Liquid and Amorphous Metals I: Fragility and Dynamics of Metallic Glasses

Time: Monday 10:15–11:45 Location: H 0107

MM 4.1 Mon 10:15 H 0107

Thermodynamic Properties of Zr- and Au-based Bulk Metallic Glasses at Very Low Temperatures — •Andreas Reifenberger, Daniel Rothfuss, Andreas Fleischmann, Andreas Reiser, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg, INF 227, 69120 Heidelberg

Many low temperature properties of glasses can be described by the standard tunnelling model. Dielectric glasses and metallic glasses in the superconducting state far below T_c ought to yield similar results since their behaviour is dominated by interactions between tunnelling systems and phonons as electrons condense to cooper pairs. We present measurements of the specific heat and thermal conductivity of superconducting bulk metallic glasses (based on Zr and Au, respectively) in the temperature range from 6 mK to 1 K. We discuss these measurements in the framework of both the BCS-theory of superconductivity and the standard tunnelling model. In the superconducting state close to T_c, where interactions with quasi-particles need to be taken into account, both measurements agree well with BCS-theory predictions. Far below T_c we find good agreements between our data and the standard tunnelling model predictions.

MM 4.2 Mon 10:30 H 0107

Time Dependent Nonlinear Response in Glassy Systems — •Birte Riechers[1], Ranko Richert[2], and Konrad Samwer[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, Germany — [2]Department of Chemistry & Biochemistry, Arizona State University, USA

Relaxation modes, especially their detailed description and understanding, play a major role for scientists working with glassy matter. One of many interesting aspects is the time scale of the change in fictive temperature under harmonic excitation in the nonlinear response regime[a].

By applying an external force sufficiently high to achieve nonlinear response, relaxation modes are excited. A time resolved measurement of the energy loss in glassy materials during a jump from the linear to the nonlinear response regime reveals the time scale of energy redistribution within the relaxation spectrum.

The behavior of plastic crystals, and metallic glasses was investigated experimentally using dielectric spectroscopy (DES), and dynamic mechanical analysis (DMA), respectively. Results are discussed with a focus on the behavior of fictive temperature regarding a connection to structural relaxation.

Financial support by the DFG Research Unit FOR 1394 is acknowledged.

[a] R.Richert, J.Chem.Phys. 130, 194509, 2009

MM 4.3 Mon 10:45 H 0107

Atomic dynamics in Zr-based glass forming melts — Sri Wayuni Basuki[1], Elisabeth Gill[1], Klaus Rätzke[1], •Franz Faupel[1], Fan Yang[2], and Andreas Meyer[2] — [1]Univ. Kiel, Chair for Multicomponent Materials, D-24143 Kiel, Germany — [2]DLR, D-51170 Köln, Germany

Recently, we reported a strong decoupling of Zr-95 and Co-57 radiotracer diffusivities in a bulk metallic glass forming $Zr_{46.75}Ti_{8.25}Cu_{7.5}Ni_{10}Be_{27.5}$ melt (Vitreloy 4) far above the liquidus temperature [1] suggesting the development of solid-like, i.e. energy-landscape controlled, features already in the stable liquid state more than 300 K above the mode coupling T_c [1]. Meanwhile, we performed similar simultaneous radiotracer diffusion experiment of Co-57 and of Zr-95 in binary Zr-Ni and ternary Zr-Ni-Al alloys with a largely reduced glass-forming ability above the liquidus temperature. Here, a much less pronounced decoupling was observed. The results will be discussed in terms of recent theoretical approaches on atomic dynamics of metallic melts.

[1] S. W. Basuki, A. Bartsch, F. Yang, K. Rätzke, A. Meyer, and F. Faupel, Phys. Rev. Lett. 113, (2014) 165901

MM 4.4 Mon 11:00 H 0107

Interatomic Repulsion Controls the Fragility of Supercooled Metallic Melts — •Johannes Krausser and Alessio Zaccone — Department of Physics, Technische Universität München, 85748 Garching, Germany

We present an analytic scheme to connect the fragility and glass-forming properties of metallic glasses to the pseudopotential between ionic cores in the metal. This is achieved by a suitable approximation of the repulsive part of the interaction and by using non-affine lattice dynamics to obtain analytical expressions for the shear modulus, viscosity, and fragility in terms of the pseudopotential. Employing a one-parameter fit to experimental data for various alloys, we were able to link the steepness of the interionic repulsion to the Thomas-Fermi-screened Coulomb repulsion and to the Born-Mayer valence electron overlap repulsion (due to Pauli exclusion). This leads, for the first time, to a simple closed-form expression for the fragility of the supercooled liquid metal in terms of atomic-scale interaction parameters. In particular, a relationship of linear proportionality is found between the fragility and the energy scales of both the screened Coulomb repulsion and the valence electron repulsion due to Pauli exclusion. The new fundamental law that we discovered opens up opportunities to fabricate alloys with tailored thermo-elastic and glass-forming properties by tuning the interatomic interaction parameters via the electronic structure and chemical composition of the alloy.

MM 4.5 Mon 11:15 H 0107

Fictive temperature and glass transition temperature of a metallic glass investigated by fast scanning calorimetry — •Christian Simon, Joachim Bokeloh, Jonas Bünz, and Gerhard Wilde — Institut für Materialphysik, WWU Münster, Wilhelm-Klemm-Str. 10, 48155 Münster

The use of fast scanning calorimeters allows a new access to thermal analysis experiments on metallic glasses. The glass transition and the crystallization were often in the focus of different studies. These studies are often limited by the heating and cooling rates of the conventional devices. The fast scanning calorimeters allow the investigation of glass transition and crystallization at high rates. The fictive temperature of glass is the temperature at which the structure of an equilibrium liquid is frozen-in. The determination of the fictive temperature is usually done by a heat capacity matching method. The strong requirement of a defined thermal history is often a difficult task for the determination of fictive temperature in the case of metallic glasses. The fast scanning calorimeter allows the in-situ production of metallic glasses and thus leads to a reproducable thermal history of the sample for every single measurement. We present data from a AuSi based metallic glass investigated by a fast scanning calorimter (50 K/s - 20 000 K/s). The obtained data cover a wide kinetic regime and are discussed with respect of deviations from Arrhenius behavior at higher heating rates.

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