MM 44: Topical Session (Symposium EPS and MM): Mechanical Properties at Small Scales

Metallic Glass

Time: Wednesday 17:00–18:15 Location: H 0107

Topical Talk MM 44.1 Wed 17:00 H 0107

Atomistic plasticity mechanisms in metallic glass thin films : new insights from advanced transmission electron microscopy — •Hosni Idrissi[1], Matteo Ghidelli[1,3,4,5], Sebastien Gravier[4], Jean-Jacques Blandin[4], Jean-Pierre Raskin[3], Dominique Schryvers[2], and Thomas Pardoen[1] — [1]Institute of Mechanics, Materials and Civil Engineering. Université Catholique de Louvain. Louvain-la-Neuve. Belgium — [2]Electron Microscopy for Materials Science (EMAT). University of Antwerp. Antwerp. Belgium — [3]Institute of Information and Communication Technologies, Electronics and Applied Mathematics. Université Catholique de Louvain. Louvain-la-Neuve. Belgium — [4]Science and Engineering of Materials and Processes, SIMaP. Université de Grenoble. Grenoble. France — [5]Micro- and Nanostructured Materials Laboratory, Department of Energy, Politecnico di Milano. Milano. Italy

Although intensive research on the deformation and fracture mechanisms has been performed on metallic glasses (MGs), the fundamental mechanisms governing the mechanical behaviour as well as the recently observed mechanical size effects in this class of materials are still not fully understood. In the present study, quantitative nanobeam electron diffraction and aberration corrected TEM techniques have been used to investigate the elementary plasticity mechanisms activated in amorphous ZrNi freestanding thin film MGs exhibiting exceptional mechanical properties uncharacteristic of metallic glasses with a yield strength close to the theoretical value (3 GPa), as well as highly enhanced ductility (up to 15%!).

MM 44.2 Wed 17:30 H 0107

Deformation and failure mechanisms of metallic glass nanostructures — •Mehdi Jafary-Zadeh[1], W. Gu[2], R. Liontas[2], S.W. Lee[2], J Greer[2], and Y.W. Zhang[1] — [1]Institute of High Performance Computing (IHPC), A*STAR, Singapore 138632 — [2]Department of Materials Science and Engineering, California Institute of Technology (Caltech), USA

Metallic glasses (MGs) are at the cutting-edge of materials research in advanced applications such as nano-electro-mechanical systems (NEMS). The overall mechanical response of MGs is a combination of their intrinsic properties, e.g. chemical composition, atomistic structure, etc., and extrinsic factors, e.g. sample size, structural flaws, and structural hierarchy. Here, we report our recent works on fabrication and in situ fracture testing of nanosize MG structures with geometries ranging from simple nanopillars to complex nanolattices, i.e. metamaterials [1-3]. We also employ large-scale molecular dynamics (MD) simulations to reveal insights into the underlying atomistic mechanisms of the rich spectrum of deformation modes. We demonstrate the importance of processing and post-processing conditions in achieving MGs with certain intrinsic features such as atomic-level structure. We show that an extrinsic flaw (notch) can shift the failure mode from shear banding to cavitation and crack propagation [2]. We further present that in hollow-tube nanolattices, the shell thicknesses leads to a unique transition in deformation mode [3].

[1] Acta Materialia 118, 270-285 (2016) [2] Nano Letters 14, 5858 (2014) [3] Nano Letters 15, 5673 (2015).

MM 44.3 Wed 17:45 H 0107

Interface mediated creep behavior of Cu-Zr metallic glass composites — •Constanze Kalcher, Tobias Brink, and Karsten Albe — Technische Universität Darmstadt, Fachbereich Material- und Geowissenschaften, Fachgebiet Materialmodellierung, Otto-Berndt-Str. 3, D-64287 Darmstadt, Germany

Metallic glasses are known for their high yield strength and resilience, but their most severe shortcoming remains the brittle failure mechanism due to strain localization. A more homogeneous deformation behavior at room temperature can be enforced by including crystalline secondary phases. Their role in the deformation behavior under creep conditions, however, has not been fully assessed. In this molecular dynamics study, we show that the properties of the glass-crystal interfaces in such composites directly influence the creep behavior. To that end we model a $Cu_{64}Zr_{36}$ metallic glass with different phase fractions of the reinforcing Cu_2Zr Laves phase and manipulate the glass-crystal interfaces by disturbing the atomic structure in the immediate neighborhood of the crystallites. The different samples are then probed under the same creep conditions. In analogy to Borisov's model for grain boundary diffusion, we observe that the creep rates of the metallic glass composites scale exponentially with the excess energy of the disturbed interfaces.

MM 44.4 Wed 18:00 H 0107

Viscoelastic stress relaxation of amorphous TiAl thin film under tension measured by selected area electron diffraction — •Christian Ebner[1], Rohit Sarkar[2], Jagannathan Rajagopalan[2], and Christian Rentenberger[1] — [1]University of Vienna, Physics of Nanostructured Materials, Boltzmanngasse 5, 1090 Vienna, Austria — [2]Arizona State University, Department of Materials Science and Engineering, School for Engineering of Matter Transport and Energy, Tempe 85287, USA

Amorphous samples loaded by an external stress show a time-dependent viscoelastic strain response. To study this behaviour on small scaled samples, in-situ tensile tests are performed on amorphous TiAl in a Philips CM200 transmission electron microscope. Selected area electron diffraction (SAED) is used as a method to extract the local atomic-level elastic strain, since elliptic distortions of the radial intensity maxima positions are introduced in the SAED patterns by tensile straining [1]. By precisely measuring these distortions, the 2-dimensional strain tensor is calculated with respect to a reference pattern. This allows to quantify the principal strain e_1 (parallel) and e_2 (perpendicular to the loading direction) as a function of the external stress σ. The viscoelastic response to stress jumps is measured by the time dependent changes in principal strain Δe_1.

[1] Ebner et al. (2016) Ultramicroscopy, 165, 51-58.

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