MM 36: Topical Session: TEM-Symposium - Structure-Property / In-Situ II

Time: Wednesday 11:45–13:00 Location: H25

MM 36.1 Wed 11:45 H25

A novel technique for measuring density changes in shear bands of metallic glasses — •Harald Rösner[1], Christian Kübel[2,3], Martin Peterlechner[1], Joachim Bokeloh[1], and Gerhard Wilde[1] — [1]Institut für Materialphysik, WWU Münster, Wilhelm-Klemm-Str. 10, D-48149 Münster, Germany — [2]Karlsruhe Institute of Technology (KIT), Institute of Nanotechnology (INT), — [3]Karlsruhe Nano Mircro Facility, Karlsruhe Institute of Technology, D-76344 Eggenstein-Leopoldshafen, Germany

The deformation process in glasses is different from that in crystalline materials because there is no crystal lattice and consequently no defects such as dislocations, twins or grain boundaries are available as deformation carriers for an easy flow mechanism. Deformation tests on glasses have shown that when the applied load exceeds the elastic range the plastic flow is confined to narrow regions called shear bands. In TEM, shear bands are distinguished from the surrounding amorphous matrix as regions of lower contrast, which is thought to be associated with an increase in free volume and thus a lower density. We describe here a new approach to measure density changes between the amorphous matrix and the shear bands of metallic glasses using the information from electron-energy loss spectra (EELS) and the high-angle annular dark-field scanning transmission electron (HAADF-STEM) signal. We found for melt-spun Al88Y7Fe5 ribbons, surprisingly, an enormous decrease in density in the sheared zones of 6.7%, which we associate with the free volume in the shear bands.

MM 36.2 Wed 12:00 H25

Ordering in deformed bulk metallic glasses studied by TEM — Christoph Gammer[1], Denise Beitelschmidt[2], Simon Pauly[2], David Geist[1], Jürgen Eckert[2], Hans-Peter Karnthaler[1], and •Christian Rentenberger[1] — [1]Universität Wien, Physik Nanostrukturierter Materialien, Boltzmanngasse 5, 1090 Wien, Austria — [2]IFW Dresden, Institut für Komplexe Materialien, Helmholtzstraße 20, 01069 Dresden, Germany

Bulk metallic glasses are characterized by an amorphic atomic arrangement, still it is assumed that some medium range order (MRO) is present. This contributes to many outstanding properties as high strength, high elastic limits and in special cases combined with some plasticity. Despite intense research activities, the details of the structure are generally not well understood. Here we use transmission electron microscopy (TEM) methods to study the structure of an bulk metallic CuZrAlAg glass. The medium range order of the amorphous structure is unravelled experimentally using fluctuation electron microscopy that measures statistical fluctuations in the scattering of electrons as a function of spatial frequencies [1]. Based on this coarse graining TEM method the intensity fluctuations in dark-field images indicate the presence of B2 like medium range order. The differences in the MRO of as cast and deformed bulk metallic CuZrAlAg glass are investigated.

[1] M.M.J. Treacy and J.M. Gibson, Acta Cryst. 52 (1996) 212.

MM 36.3 Wed 12:15 H25

In situ TEM deformation of Au nanowires — •Burkhard Roos[1], Bahne Kapelle[1], Torben Erichsen[1], Gunther Richter[2], and Cynthia A. Volkert[1] — [1]Institut für Materialphysik, Universität Göttingen — [2]Max-Planck-Institut für Intelligente Systeme, Stuttgart

Increasing strength with decreasing size is a common phenomenon in metals, and is often explained in terms of dislocation pile-ups and interactions. However, for free standing samples with dimensions below 150 nm, dislocation storage is hard to envision and a convincing explanation for the high strength is still missing. The goal of this study is to directly observe dislocations in small volumes, using in situ TEM during deformation. Single crystal Au nanowires with diameters between 40 and 250 nm have been used for this study. Stacking faults appear during tensile deformation as a result of the nucleation and motion of partial dislocations. The stacking faults form homogenously along the wire length on {111} planes. The stacking faults thicken into nanotwins through the sequential activation of partial dislocations on neighbouring (111) planes. Post-deformation TEM studies show that fracture occurs at a nanotwin. In contrast bending of identical wires leads to the nucleation of full dislocations. A quantitative model based on classical nucleation theory will be presented which explains the observed difference in deformation mode. Implications for different materials and loading geometries will be discussed.

Topical Talk MM 36.4 Wed 12:30 H25

In-situ transmission electron microscopy — •Henny Zandbergen — Kavli Institute of Nanoscience, TUDelft, Delft, The Netherlands

After a decade of great improvements in the optical performances of high-resolution electron microscopes, the developments in the next decade of transmission electron microscopy (TEM) will be mainly in the development of in-situ electron microscopy and 3D analysis on the atomic level. In Delft we have focused on in-situ (TEM), using in part MEMS (micro electro mechanical systems) devices to overcome size related problems due to the limited available space in the TEM for sample manipulation. In Delft we are using routinely MEMS based holders for heating, for applying electrical currents and heating under a gas atmosphere.

In the talk in-situ TEM examples will be given of electromigration in metal nanobridges, (de)hydrogenation of hydrogen storage materials, changes in the shapes and crystal structures of semiconductor nanoparticles and the sculpting of grapheme into nanoribbons.