# MM 4: Topical session (Symposium EPS and MM): Mechanical Properties at Small Scales

Plasticity: Experiments

EPS-Symposium organized by Laurent Pizzagalli (U Poitiers, France), Gerhard Dehm (MPI Eisenforschung, Düsseldorf, Germany), Olivier Thomas (U Aix-Marseille, Marseille, France), and Jörg Neugebauer (MPI Eisenforschung, Düsseldorf, Germany).

Time: Monday 10:15–11:30 Location: TC 006

**Topical Talk** MM 4.1 Mon 10:15 TC 006

**Plasticity in complex crystals * On the role of building blocks in intermetallics and layered compounds** — •Sandra Korte-Kerzel[1], Sebastian Schröders[1], Stefanie Sandlöbes[1], James Gibson[1], and William Clegg[2] — [1]Institut für Metallkunde und Metallphysik, RWTH Aachen University, Aachen, Germany — [2]Department of Materials Science and Metallurgy, University of Cambridge, UK

Plasticity in most complex crystals remains poorly understood owing to their brittleness and the associated difficulties in mechanical testing. The development of microcompression and its use in conjunction with electron microscopy has been a major step forward and systematic studies are now possible [1]. However, the uncharted phase space in terms of plastic deformation remains vast. In this context, the role of recurring building blocks in complex crystals and how plasticity may be governed by smaller elements in large unit cells is discussed in the light of intermetallic and atomically layered phases. Taking the extraordinary properties of MAX phases [2] and the topologically close packed $\mu$-phase with its Laves building blocks as example, small-scale testing in conjunction with electron microscopy to atomic resolution and density functional theory calculations was used to elucidate the key components of the respective large unit cells.

[1] Korte-Kerzel, S. Microcompression of brittle and anisotropic crystals, MRS Comm 1-12 (2017) [2] Howie, P.R., Thompson, R. J., Korte-Kerzel, S., Clegg, W.J. Softening non-metallic crystals by inhomogeneous elasticity, Sci Rep 7, 11602 (2017)

MM 4.2 Mon 10:45 TC 006

**Insights into the deformation behavior of the superplastic alloy Zn22Al at the micro-scale** — •Patrick Feldner, Benoit Merle, and Mathias Göken — Friedrich-Alexander-University Erlangen-Nuremberg, 91054 Erlangen, Germany

Due to their remarkable ductility, superplastic metallic alloys are promising candidates to create micro-scale components via microforming processes. However, it has not yet been established if the macroscopically observed superplastic behavior also persists at microscopic length scales.

For this reason, the superplastic alloy Zn22Al was characterized at small length scales using nanoindentation at elevated temperatures, pillar compression experiments as well as tensile testing in situ in a TEM.

Coupling the local strain-rate sensitivity with the apparent activation energy, strong evidences for superplastic like flow at the micrometer-scale were found. However, further successively decreasing the size of the plastic zone yields a significant change of the deformation kinetics, which suggests a critical length scale beneath which the superplastic material behavior disappears.

Supported by the deformation and fracture mechanisms observed during thin film tensile testing, a transition from boundary mediated ductility to boundary mediated brittleness is proposed.

MM 4.3 Mon 11:00 TC 006

**Plastic Poisson's Ratio of Nanoporous Metals: A Macroscopic Signature of Tension-Compression Asymmetry at the Nanoscale** — •Lukas Lührs[1], Birthe Zandersons[1], Norbert Huber[2,1], and Jörg Weissmüller[1,2] — [1]Institute of Materials Physics and Technology, Hamburg University of Technology — [2]Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht

At small length scales atomistic simulations suggest a surface-induced tension-compression asymmetry of the strength and flow stress of metallic bodies. As experimental evidence supporting this notion remains to be reported, we investigate the impact of capillary forces on small-scale plasticity.

We study the transverse plastic deformation of macroscopic nanoporous gold under uniaxial compression in electrolyte. This affords in situ variation of the surface state, specifically the surface tension, $\gamma$, during plastic flow. We find that decreasing $\gamma$ results in an increase of the macroscopic plastic Poisson's ratio, $\nu_\mathrm{P}$. We show that $\gamma$ promotes the compression while hindering tensile elongation of individual ligaments. Transverse deformation during compression of the network structure is partly caused by the stretching of ligaments oriented perpendicular to the load axis. Here, the surface-induced tension-compression asymmetry acts to reduce $\nu_\mathrm{P}$. Finite element simulations support experimental observations and confirm the significant contribution of the surface tension to small-scale plasticity.

[Nano Lett., 2017, 17 (10), 6258-6266]

MM 4.4 Mon 11:15 TC 006

**Electro-plastic deformation studies of Al-Cu eutectic alloys** — •Doreen Andre, Stefanie Sandlöbes, and Sandra Korte-Kerzel — Institut für Metallkunde und Metallphysik, RWTH Aachen 52056 Aachen, GERMANY

A promising approach of forming materials with poor deformation behaviour, such as metallic-intermetallic composite materials, here an Al-Cu eutectic alloy, is to apply electric pulses during the forming processes. This effect is known as the electro-plastic effect (EPE). The EPE causes a drop in the yield strength resulting in higher formability of materials. However, the underlying physical mechanisms are not fully understood yet. Since the EPE has only been studied on the macroscopic scale until now, we have modified our nanoindenter device such that we can apply electrical pulses during nanoindentation and micro-pillar compression. This enables us to study the effects of electrical pulses during plastic deformation of single-phase and single-crystalline samples of even complex microstructures, hence, providing more detailed insights into the physical nature of the electro-plastic effect. Additionally, high current densities can be achieved due to the small tested sample volumes. Here, we present our experimental set-up and report about first experimental results of a nano-mechanical electro-plastic study on an Al-Cu eutectic alloy.