MM 37: Biomaterials and Biological Materials II

Time: Wednesday 11:45–13:15 Location: TC 006

MM 37.1 Wed 11:45 TC 006

Smart wooden actuators — •Markus Rüggeberg[1,2], Mohammad M. Hassani[1], Chiara Vailati[1,2], Falk Wittel[1], Hans J. Herrmann[1], and Ingo Burgert[1,2] — [1]ETH Zürich, Institute for Building Materials, Zürich, Switzerland — [2]Empa, Applied Wood Materials, Dübendorf, Switzerland

Wood swells and shrinks when exposed to fluctuating relative humidity. This property is a drawback for the use of wood as construction material. On the other hand the dimensional instability is the basis for creating smart, autonomously controlled actuators. Nature has developed numerous actuators responding to alternating relative humidity. In pine cones, wheat awns and orchid tree seedpods, the dimensional changes are transformed to bending and twisting movements by creating bi-layered structures with specific fibre orientations in the individual layers. Inspired by these plant model systems, we have developed convertible wooden elements. In outdoor applications, these elements respond to the daily alteration of relative humidity. Therefore, the movement of these elements is autonomous and solar driven. We compare experiments with numerical predictions using a rheological model of wood. A history dependent moisture-stress analysis using the developed material model under changing climatic condition is performed, to predict the true stress and deformation state. Possible applications are facades, or carriers of solar panels which autonomously track the sun. Upscaling of the actuators have already been demonstrated and a prototype of a carrier for solar panels has been successfully tested.

MM 37.2 Wed 12:00 TC 006

Moisture driven actuation of silica structures replicated from pine cone scales — •Gerhard Fritz-Popovski[1], Daniel Van Opdenbosch[2], Roland Morak[1], Oskar Paris[1], and Cordt Zollfrank[2] — [1]Institute of Physics, Montanuniversitaet Leoben Franz-Josef-Str. 18, 8700 Leoben, Austria — [2]Fachgebiet Biogene Polymere, Technische Universität München am Wissenschaftszentrum Straubing Schulgasse 16, D-94315 Straubing, Germany

The actuation behavior of silica structures that were based on the templates of pine cones was investigated. The silica structure replicated all structures from the macroscopic level down to the level of microfibrils (diameter 10-20 nm). While the movement of native pine cones is based of different swelling of the fibrous materials in fiber direction and normal to it the biotemplated silica material contains no fibers but pores. Nevertheless, the inorganic material shows similar moisture dependent movements as the biological one. This can be explained by different elastic deformation of the pores along and normal to the axis during vapor condensation.

MM 37.3 Wed 12:15 TC 006

Self-folding polymer films for cell encapsulation and release — •Vladislav Stroganov and Leonid Ionov — Leibniz-Institut für Polymerforschung Dresden e.V., Dresden, Deutschland

Asymmetry is intrinsic to natural systems and is widely used by living organisms for efficient adaptation, mimicry and movement. Polymer bilayers are the example of synthetic asymmetric systems, which are able to generate macroscopic motion and fold by forming different 3D objects such as tubes and capsules. Similar to bimetal films, the polymer bilayer consist of two substances with different swelling properties. One polymer is non-swellable and hydrophobic. Another polymer is water-swellable hydrogel. The folding, which might occur in response to temperature or pH, is caused by swelling of the hydrogel layer. The formed tubes and capsules can be manipulated using magnetic field. Reversible folding and unfolding of the polymer films is applied for reversible capture and release of cells in response to change of temperature and other signals. This novel biomimetic approach can be used for controlled encapsulation and release of microparticles, cells and drugs as well as fabrication of 3D scaffolds for tissue engineering.

Topical Talk MM 37.4 Wed 12:30 TC 006

Architectured strength: when tasty nuts and teeth meet: — •Claudia Fleck[1], Paul Zaslansky[2], Wolf-Dieter Müller[3], Andreas Bührig-Polaczek[4], and Thomas Speck[5] — [1]Materials Engineering, Institute of Technology, Berlin, Germany — [2]Julius-Wolff-Institute, Charité, Berlin, Germany — [3]Biomaterials Research and Dental Materials Science, Charité, Berlin, Germany — [4]Foundry Institute, RWTH, Aachen, Germany — [5]Plant Biomechanics, University Freiburg, Freiburg, Germany

In nature, damage tolerant tissues or organs ensure survival, by failing safely. Failure of the whole structure is delayed to allow repair processes, or it is even stopped, leaving behind a locally damaged, but still functioning entity. Many damage tolerant structures exist, even without self-healing capacity, and often the border between material and architecture is blurred. Mammalian teeth and Macadamia nutshells are two impressive examples. Chewing loads on whole teeth are distributed and transferred into the jaw bone by an intricate architecture of hard and soft materials, preventing failure even over millions of loading cycles. Macadamia nutshells protect the seed, despite numerous inner notches, by a multi-level sandwich and foam structure paired with a ball-like macro-geometry. We apply mechanical testing, in situ with light/electron microscopy or lab/synchrotron microtomogrpahy, together with FE-calculations, to characterize the structural reasons of failure resistance, and we aim at developing architectured metal or ceramic constructs with enhanced damage tolerance as compared to the monolithic materials.

MM 37.5 Wed 13:00 TC 006

Mapping internal mineral strains in human dentine under tension: X-ray diffraction insights into the contribution of the mineral nano-particles to the load-bearing capacity of tooth tissue — •Jean-Baptiste Forien[1], Claudia Fleck[2], Peter Fratzl[3], and Paul Zaslansky[1] — [1]Julius Wolff Institut, Berlin, Germany — [2]Technical University, Berlin, Germany — [3]Max Planck Institute of Colloids and Interfaces, Potsdam, Germany

Teeth are hierarchical strong and stiff structures, consisting of a mineralized protein-based composite (dentine). They function under mechanical load, and the nanometer-sized hydroxyapatite mineral particles in the collagen fiber matrix deform as a response to applied external stress (Deymier-Black,2012). In this study, we report on the mineral response in human dentine to mechanical tensile testing. We track mineral particles following changes in the mineral dimension using X-ray diffraction. It is thus possible to compare the stresses experienced by the mineral particles with the stress applied by the external load. We find that the tissue to mineral strain ratios observed increase until they reach a value of 2, which is three times lower than for bone (Gupta,2006), and suggests that a different load-partitioning mechanism exists in teeth. We also find that the Poisson's ratio decreases with increasing load, suggesting that as load increases, there is some dynamic change in the loads transferred to the crystals, similar to what was found for bovine dentine loaded in compression. With increasing load, more strain-energy is orientated along the tensile axis and less is distributed into particles oriented along other orientations.