Mechanical and hydro-mechanical in situ micro X-ray computed tomography investigations at the PML

Matthias Ruf[1], Holger Steeb[1,2]

[1]) University of Stuttgart, Institute of Applied Mechanics (CE), Pfaffenwaldring 7, D-70569 Stuttgart, Germany
matthias.ruf@mechbau.uni-stuttgart.de
[2]) University of Stuttgart, SC SimTech, D-70569 Stuttgart, Germany

To characterize and understand the morphology of materials and components, micro X-ray Computed Tomography (µXRCT) imaging [1, 2] has become a standard three-dimensional imaging method in many research fields. It offers the possibility of providing microstructural information from the micrometer to the centimeter scale in a non-invasive way.

For various classes of materials, it is well known that the inherent morphology is tremendously changed if the material deforms. Prominent examples are (soft) cellular materials like polymer foams, where morphological properties, like intrinsic porosity, strongly depend on the deformation state. µXRCT-based characterization of the evolution of morphological properties at different deformation states provides novel and important insight as well as understanding of the material's behavior. Further, it allows to combine effective material properties on the macro- (sample) scale, like elastic moduli or strength, with the morphology on the micro-scale. Commonly, such investigations are denoted as "in situ µXRCT" whereby the sample is tested inside the µXRCT-system [3].

At the Porous Media Lab (PML) of the Institute of Applied Mechanics (CE) of the University of Stuttgart, an open, modular, and highly flexible µXRCT-system was developed and built-up [4]. Meanwhile, the system was extended by a load frame in order to perform mechanical and hydro-mechanical in situ investigations in a versatile manner. A universal testing device with two integrated rotational tables was implemented for this. In particular, in situ compressive, tensile, and torsional studies and their combinations (parallel or sequential) can be performed. Furthermore, hydro-mechanical coupled phenomena can be investigated using appropriate equipment, such as triaxial flow cells. Within this contribution, the available possibilities are presented based on different performed investigations. One example focuses on the load-sequence behavior of open-cell reticulated polyurethane (PU) foam. Another example demonstrates the capabilities in the context of fracture mechanics by a confined compressive strength test of a rock sample in a triaxial cell.

References

[1] Stock, S. R. 2019. *MicroComputed Tomography: Methodology and Applications.* Boca Raton, FL: CRC Press.

[2] Withers, P. J., Bouman, C., Carmignato, S., Cnudde, V., Grimaldi, D., Hagen, C. K., Maire, E., Manley, M., Du Plessis, A. and Stock, S. R. 2021. X-ray computed tomography. *Nature Reviews Methods Primers* 1(18).

[3] Buffière, J. Y., Cloetens, P., Ludwig, W., Maire, E., Salvo, L. 2008. In situ X-ray tomography studies of microstructural evolution combined with 3D modeling. *MRS Bulletin* 33(6):611–619.

[4] Ruf, M. and Steeb, H. 2020. An open, modular, and flexible micro X-ray computed tomography system for research. *Review of Scientific Instruments* 91(11):113102.