

Ralf Jänicke

“Multiscale and multifield problems in porous media: Modeling, simulations and experiments”

Material properties and damage evolution in engineering structures are controlled by coupled multifield processes on various length and time scales that might ultimately result in the collapse of the entire structure. Often, such deterioration processes are driven by transport of a liquid phase or further mobile species (e.g. Chloride ions in concrete, Lithium ions in a battery electrolyte) through pore networks or along highly conductive fractures embedded in a solid phase. In this presentation, we will put particular emphasis on diffusion processes in porous media across several length scales, namely the pore scale, an intermediate continuum scale with spatially varying material properties and, finally, the scale of observable macroscopic (effective) material properties. We will present strategies to bridge the scales by means of Variationally Consistent Homogenization resulting in a FE2 problem. Moreover, we will show that computational costs can be reduced significantly upon employing Numerical Model Reduction based on snapshot POD. Hereby, local transport processes, i.e. transport processes on the length scale smaller than a Representative Volume Element, are no longer resolved during the “online”-phase of the computation but reduced to the problem of solving a set of ODEs in conjunction with the FE-problem on the larger scale. The relevant material properties can be computed in an inexpensive way beforehand during an “offline” phase. Finally, we’ll give an outlook on experimental techniques to observe and quantify diffusion processes in porous by means of 3D-imaging. Trial to test the efficacy of new treatments.



Prof. Dr.-Ing. Ralf Jänicke is the director of the Institute of Applied Mechanics at Technische Universität Braunschweig, Germany. Ralf Jänicke got his PhD (Dr.-Ing.) 2010 at Saarland University, Germany. From 2010-2016, he worked as a lecturer at Ruhr-Universität Bochum, Germany, where he also finalized his habilitation thesis (venia legendi) in Mechanics. In 2016, he joined the Division of Material and Computational Mechanics at Chalmers University of Technology, Sweden, where he was engaged as an Associate-Professor in Solid and Structural Mechanics. Since 2021, he is head of the Institute of Applied Mechanics at Technische Universität Braunschweig, Germany. Ralf’s research interests are about modeling and simulation of transport in porous media with applications ranging from rock physics to structural engineering and materials science. He is particularly interested in fast and data-efficient multi-scale simulation techniques (Numerical Model Reduction).