A fully-homogenized multiphysics model for a reversible solid oxide cell stack

In electrochemical devices such as solid oxide cell stacks, many physical phenomena are interacting on many different length scales in an intricate geometry. Modeling is a strong tool to understand the interior of such devices during operation, enhance their design and investigate long-term response (degradation). Computations can however be challenging as the many geometric details and coupled physical phenomena require a significant computational power, and in some cases, even state-of-the-art clusters will not be sufficient. This hinders the use of the models for the further development of the technology. In this work, we present an original type of solid oxide cell stack model, which is highly computationally efficient, resulting in computations which are two orders of magnitude faster than the conventional type of stack models with all geometric details explicitly represented. In the model presented here, the geometric details are implicitly represented by using the so-called homogenization. The resulting homogeneous anisotropic media provides the correct overall response (temperature, species, molar fractions, etc.). Local details as the mechanical stress in the electrolyte are not represented explicitly. These can be retrieved by localization through sub-models (multiscale model), in some cases without loss of computational efficiency, as demonstrated.