Numerical Modeling of a Serpentine Channel SOFC for Elevated Pressure Applications

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Abstract

Solid oxide fuel cell (SOFC) is a kind of high-temperature fuel cell which directly converts the chemical energy of the fuel into the electrical energy. The high efficiency and fuel flexibility of the SOFC has widened its applications in the field of energy. In the present study, a 3-D CFD model is used to study the effect of temperature on an elevated pressure operated anode-supported planar SOFC using COMSOL Multiphysics. An SOFC possessing serpentine channel with 150 μm anode, 35 μm electrolyte and 50 μm cathode thickness is developed to investigate the consequences of the temperature at the ambient and elevated pressure on SOFC output power.

In the present model, the Navier-Stokes equation is used to compute fluid flow variables in the cathode and anode channels while the Brinkman equation is used to study the flow through the porous medium. These are done using the porous media and subsurface flow module in COMSOL Multiphysics®. The Maxwell-Stefan diffusion model is implemented to study mass transport properties using the transport of concentrated species module. The heat equation coupled with electrochemical heat generation assuming the local temperature equilibrium is solved using the Heat Transfer Module. The inbuilt "Reacting flow multiphysics" option of COMSOL Multiphysics® is used to couple mass transport and electrochemical reactions at the electrode-electrolyte boundaries. The model is uniformly meshed using ~10^6 cuboidal elements customized to be finer near the reacting interfaces. A direct solver, PARDISO of COMSOL Multiphysics® is employed by setting a relative tolerance of ~ 10^-5 to solve the equations with suitable boundary conditions.

In the present investigation, the temperature is varied from 873 K to 1073 K with a corresponding variation of pressure up to an elevated pressure of 3 bar from atmospheric pressure. This study also incorporates all the overpotentials associated with the SOFC and the resultant heat generation due to these. The cell temperature, current density, and power density are investigated for the current geometry. Details will be provided in the full paper.

Figures used in the abstract

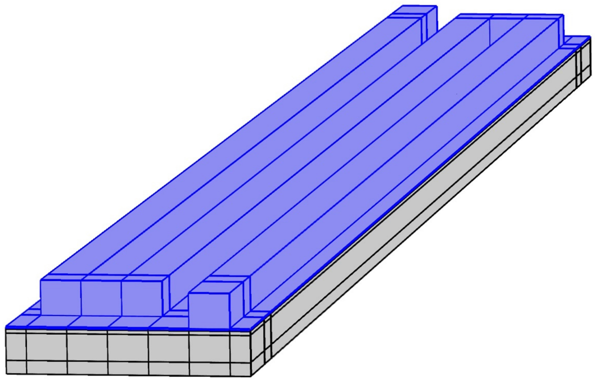

Figure 1: Serpentine Flow Geometry of an SOFC