Three-dimensional modeling of anode-supported planar SOFC with direct internal reforming
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An increased overall efficiency of Solid Oxide Fuel Cell (SOFC) systems can be achieved by direct internal reforming. Furthermore internal reforming will simplify the system design significantly. Mathematical modeling is an important tool to evaluate the performance and design, and identify and overcome the problems faced by the development of fuel cells and fuel cell systems. This paper presents a three-dimensional model of an anode-supported planar SOFC with corrugated bipolar plates serving as gas channels and current collector above the active area of cell, based on the direct internal reforming reaction of methane and the electrochemical reaction of hydrogen. A co-flow system with gas mixture of methane, water vapor and a small amount of hydrogen as anode gas and air as cathode gas fed at inlet temperature of 1073K was modeled at a single channel level. An empirical equation for the cell resistance with measured values for different parameters is used for the calculations. Conservation equations of mass, momentum, energy and species are solved incorporating the internal reforming and electrochemical reactions. Heat transfer due to conduction and convection and mass diffusion of gases inside the cell are included. The model was developed using the commercial CFD package “Fluent” and external subroutines which describe the internal reforming and electrochemical reactions and related properties of gases used. The modeling results show the detailed distribution of the current density over the active cell area and temperature and gas concentrations (fuel and air) in the PEN structure (positive electrode/electrolyte/negative electrode) and gas channels. Furthermore, the temperature gradient inside the cell was investigated and accordingly the most susceptible location of thermal stress was identified based on the modeling results. Methods for decreasing the temperature gradients and arriving at improved design are discussed.