A topology optimization method is used to identify optimal designs of the cathode microstructure and the anode support in a solid oxide fuel cell (SOFC). Two dimensional and three dimensional models are considered. A 2D topology optimization model is developed to maximize the current generated by the cathode microstructure. A simplified analysis model is used in computations. Results highlight the importance of the cathode geometry in the performance. Optimal geometric features are found to depend on the material properties and various geometric parameters. To improve upon the accuracy available from a purely 2D model, a 3D finite element model is established to make an accurate prediction of the cathode resistance. A detailed 3D microstructure geometry is reconstructed from images obtained using the 3D focused ion beam-scanning electron microscopy. Based on this model, a 3D topology optimization formulation is set up to minimize cathode resistance. The effect of the material properties on the geometric features is investigated. Significant improvements are achieved by properly organizing the cathode microstructure.

The thermal stress problem of the anode support in the SOFC stacks is also of great interest. Several complex processes including fuel flow, heat transfer, electrochemical reaction and thermo-mechanical deformation are considered in a coupled model. A Weibull distribution evaluating the probability of failure is used as a measure of the strength of the anode. A new material model is developed aiming at the topology optimization of the anode strength. Optimal designs for three types of objective functions, including minimum thermal compliance, minimum probability of failure and minimum amount of material, are obtained. It is observed that the designs obtained using the first two of the objective functions can improve the performance.