Metal-Supported Solid Oxide Fuel Cells for Rapid Thermal Cycling

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Objective: to improve rapid thermal cycling and mechanical ruggedness of solid oxide fuel cells by investigating various fuel cell geometries and supports

Background

Solid Oxide Fuel Cells (SOFCs) are a highly efficient, fuel flexible type of fuel cell with high operating temperatures ([600-900]°C) [1,2]. They operate by means of electrochemical half reactions taking place at an anode and a cathode, separated by a ceramic electrolyte. These half reactions force electrons to travel though an external circuit where they can be utilized as current to produce work.

SOFCs in particular have several hurdles to overcome before successful commercialization, these include: high cost of production (materials and manufacturing), failure due to rapid thermal cycling, failure due to mechanical shock, unreliable sealing, and failure due to oxidation at the anode [3].

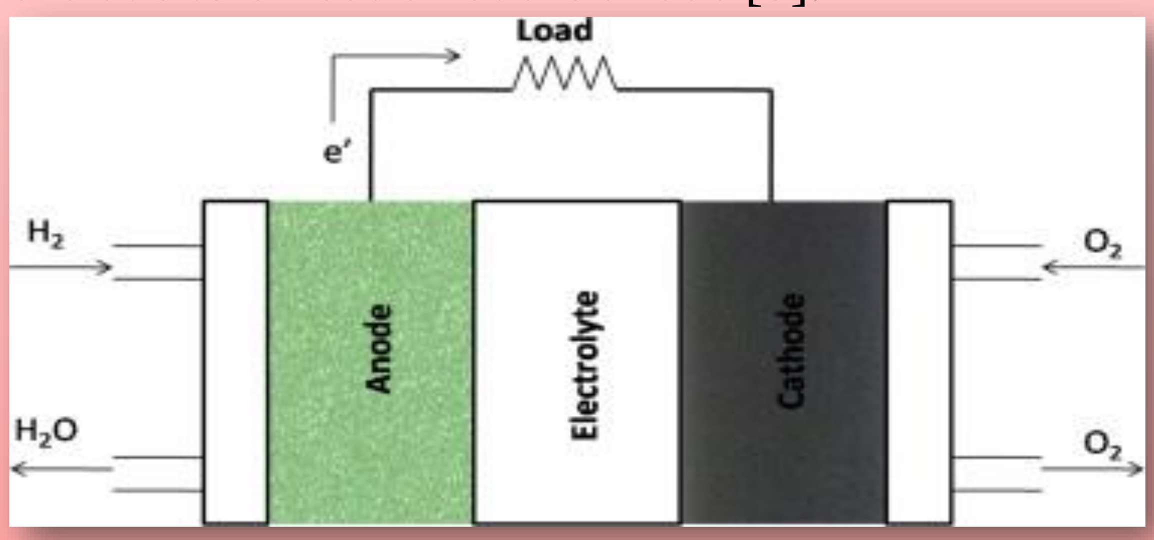

Figure 1: Schematic of single solid oxide fuel cell [2].

Supports & Configurations

Cell supports include electrolyte-supported cells (ESCs), cathode-supported cells (CSCs), and anode-supported cells (ASCs). These historic approaches have poor mechanical shock tolerance (CSCs), slow temperature ramp rates (ASCs), and comparatively high operating temperatures in the world of SOFCs (ESCs) [3,4]. By using metal-supported cells (MSCs), a number of these issues could be eliminated [3].

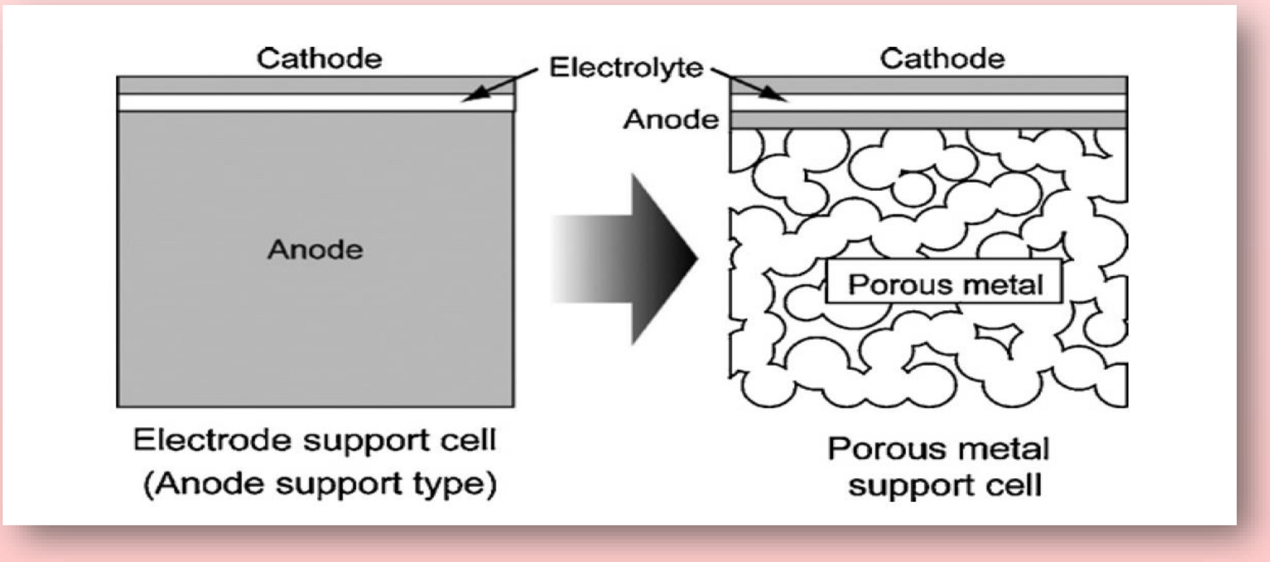

Figure 2: Schematic representation of anode supported cell (ASC) and metal-supported cell (MSC). Only a thin portion of the anode layer, as required for electrochemical function is retained in the MSC design [3].

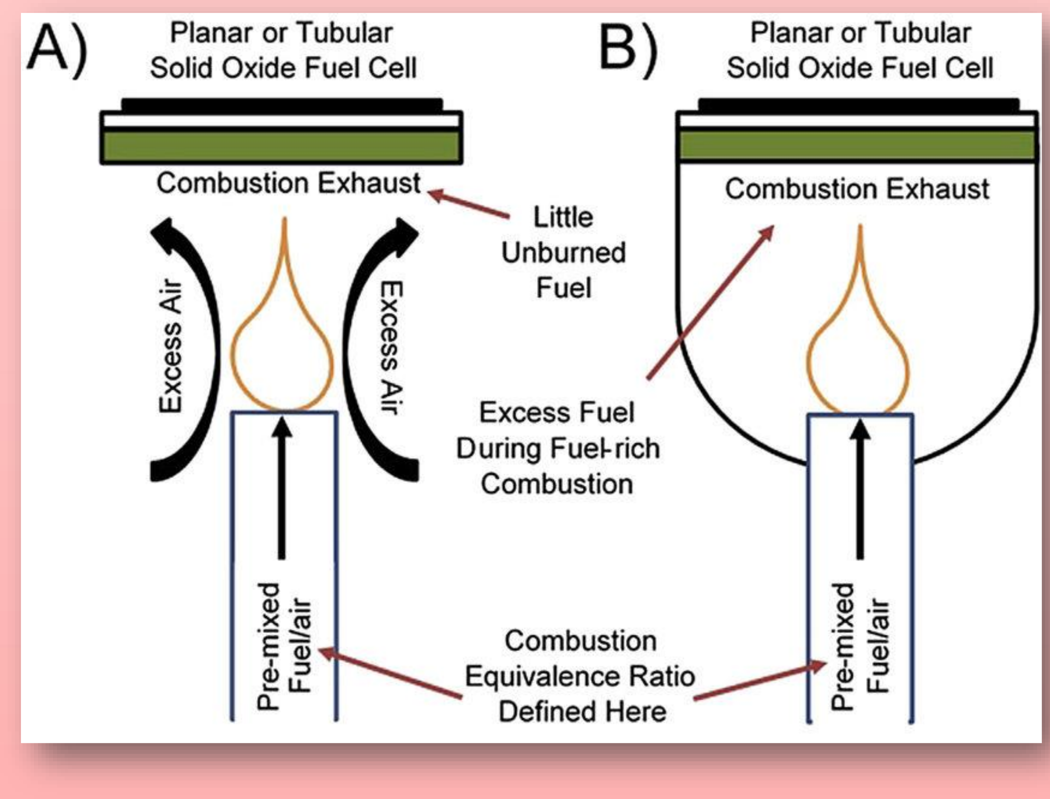

Figure 3: Schematic of the A) direct flame fuel cell (DFFC) setup compared to the B) flame-assisted fuel cell (FFC) setup [5].

Recent research by Dr. Milcarek has shown that using Flame-assisted Fuel Cells (FFCs) can drastically increase the number of thermal cycles a cell can handle [5]. There is currently insufficient research on the ability of planar SOFCs to effectively thermally cycle in a FFC configuration, and the impact that a metal-support would have in the setup, and thus is the focus of this investigation.

Reactor Design

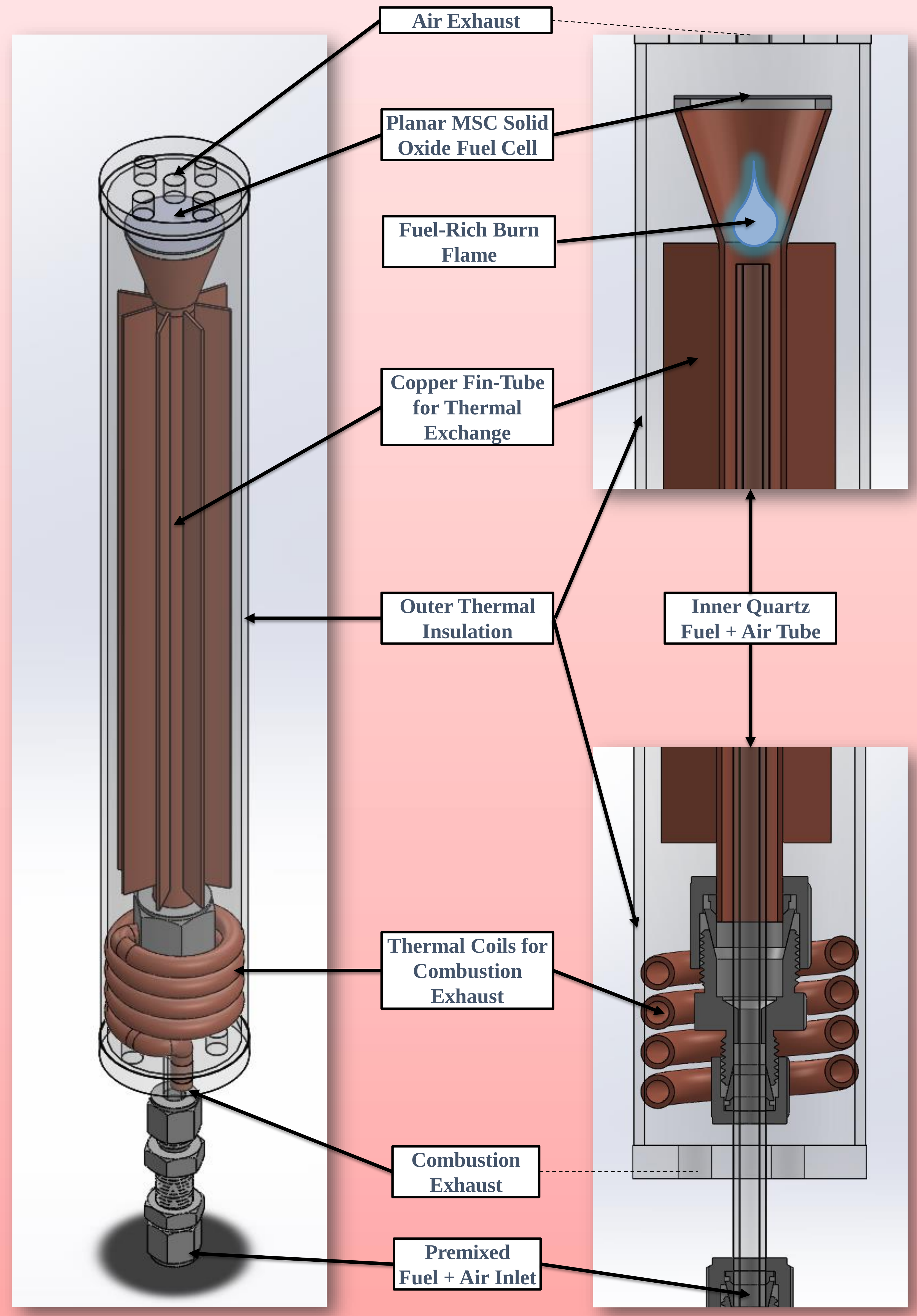

Figure 4: SolidWorks Model of Reactor Design for the Planar Flame-Assisted Metal-Supported Solid Oxide Fuel Cell

Figures 5 & 6: Mid-Plane View of Reactor Chamber

Methods and Expected Results

The current-voltage method with four probe technique will be used to analyze the electrical efficiency, power density, and polarization of the planar MSC FFC upon completion of reactor construction. Once sufficient data is obtained, the cell will be tested for its ability to thermally cycle.

We expect to see, through sufficient thermal management, significantly higher electrical efficiencies for the fuel cells in this configuration. In addition, the expected result of the thermal cycling experiments is that the MSC offers a significant increase in the number of rapid thermal cycles the system can handle before failure.

References and Acknowledgements

Many thanks to Fulton Undergraduate Research Initiative for facilitating this research project, and Dr. Michael Tucker from the Lawrence Berkeley National Laboratory for collaborating with the Combustion and Electrochemical Power Systems Lab which allowed for the procurement of the metal supported cells used.

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