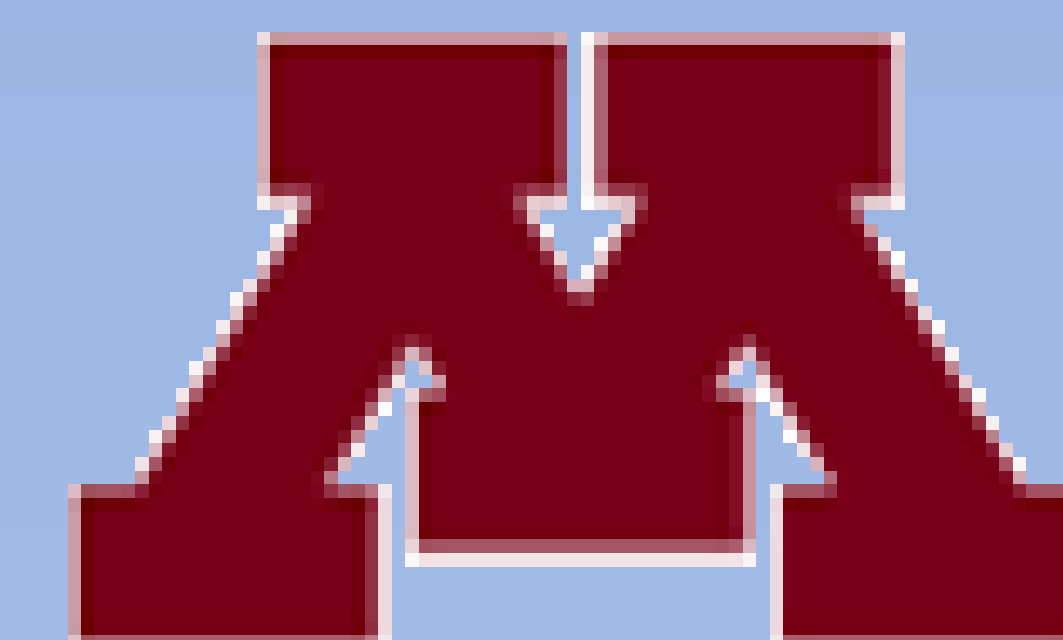


Molybdenum Dioxide As A Solid Oxide Fuel Cell Anodic Catalyst



Jay Thunstrom, Su Ha, Oscar Flores-Marins, Sean Parris, and Caleb Ellefson
Introduction to Multiscale Engineering
School of Mechanical and Materials Engineering

Introduction

With society's ever increasing use of electronic devices, transforming chemical energy into electrical energy effectively and efficiently is a main problem posed to today's scientific community. While generators accomplish the desired task, they inherently forfeit much energy to overcome frictional forces. To avoid these losses, non-mechanical devices that will stretch the efficiency boundaries of energy transformation are being developed. One of the most auspicious and the topic presented here is the solid oxide fuel cell (SOFC).

SOFCs are commercially fabricated, however, currently they only can be powered by hydrogen or very short hydrocarbon chains. If operated in the presence of excess carbon or the impurities found in fuels such as biodiesel or jet fuel, SOFC anodes are poisoned, rendering them useless. Research conducted focused on fabricating anodes based on molybdenum dioxide, which has proven to readily reform hydrocarbons and have great resistance to poisoning.

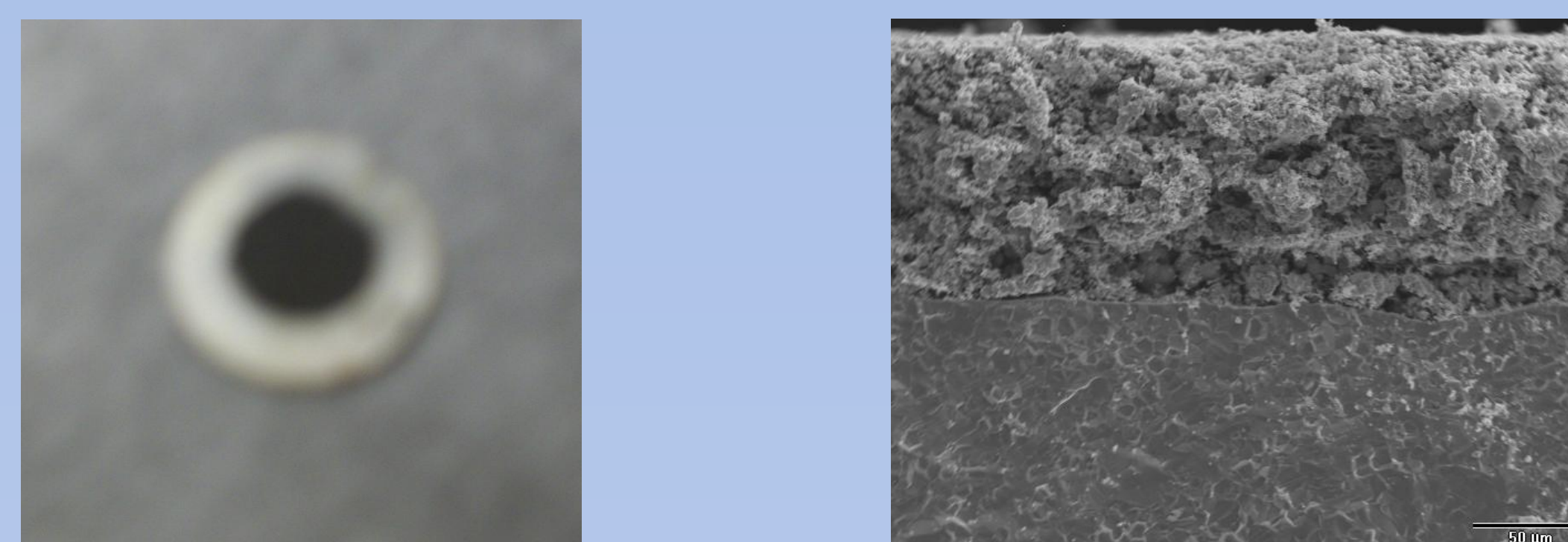
Fabrication

SOFC creation begins with the forming of the structural material, in this case, a Yttria Stabilized Zirconia (YSZ) electrolyte. Starting as a powder, the electrolyte is compressed into dense and thin (<1mm) pellet using a die and a press. Then, the electrolyte is sintered to increase its density, create oxygen vacancies which allow for oxygen ion flow, and to increase its strength.

Application of the cathode occurs next. An LSCF or similar powder is mixed with deionized water. The mixture is then painted onto one side of the electrolyte to create a thin layer. After allowing the water to evaporate from the LSCF, the half-cell is sintered again.

The anode is applied in much the same way as the cathode. A molybdenum trioxide powder is diluted with nickel oxide and YSZ powders. The combination is mixed with water and painted on the side of the electrolyte opposite the cathode. When dry, the whole cell is oxidized and reduced in a reactor to remove any organic compounds remaining in the anode and to change the oxides to the reforming catalysts molybdenum dioxide and nickel. To verify the correct compounds are deposited on the electrolyte, X-ray diffraction techniques are utilized.

Molybdenum Dioxide



Molybdenum dioxide based anode on a YSZ electrolyte (left) and a SEM picture of the anode-electrolyte boundary (right)

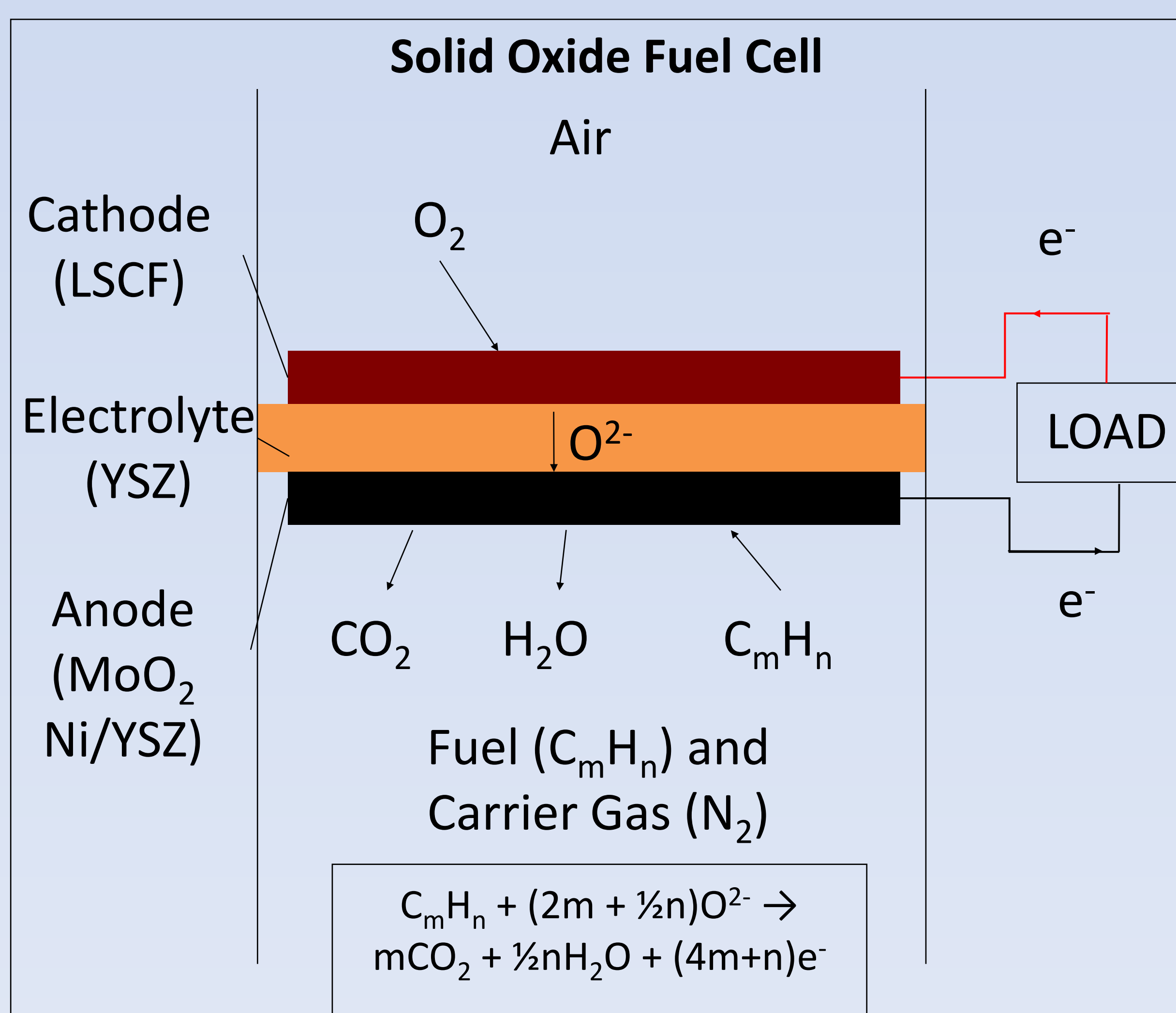
Solid Oxide Fuel Cell Operation

Three stages exist to a SOFC's operation:

Stage 1: Oxygen, generally provided directly from ambient air, contacts the cathode, which catalyzes a reaction to ionize the molecules.

Stage 2: The oxygen ions travel through a ion permeable electrolyte. This membrane is highly resistant to electron and air flow, but it allows oxygen ions to pass freely. Frequently, the electrolyte is the structural component of a SOFC. It also provides a means to seal the anode from the cathode.

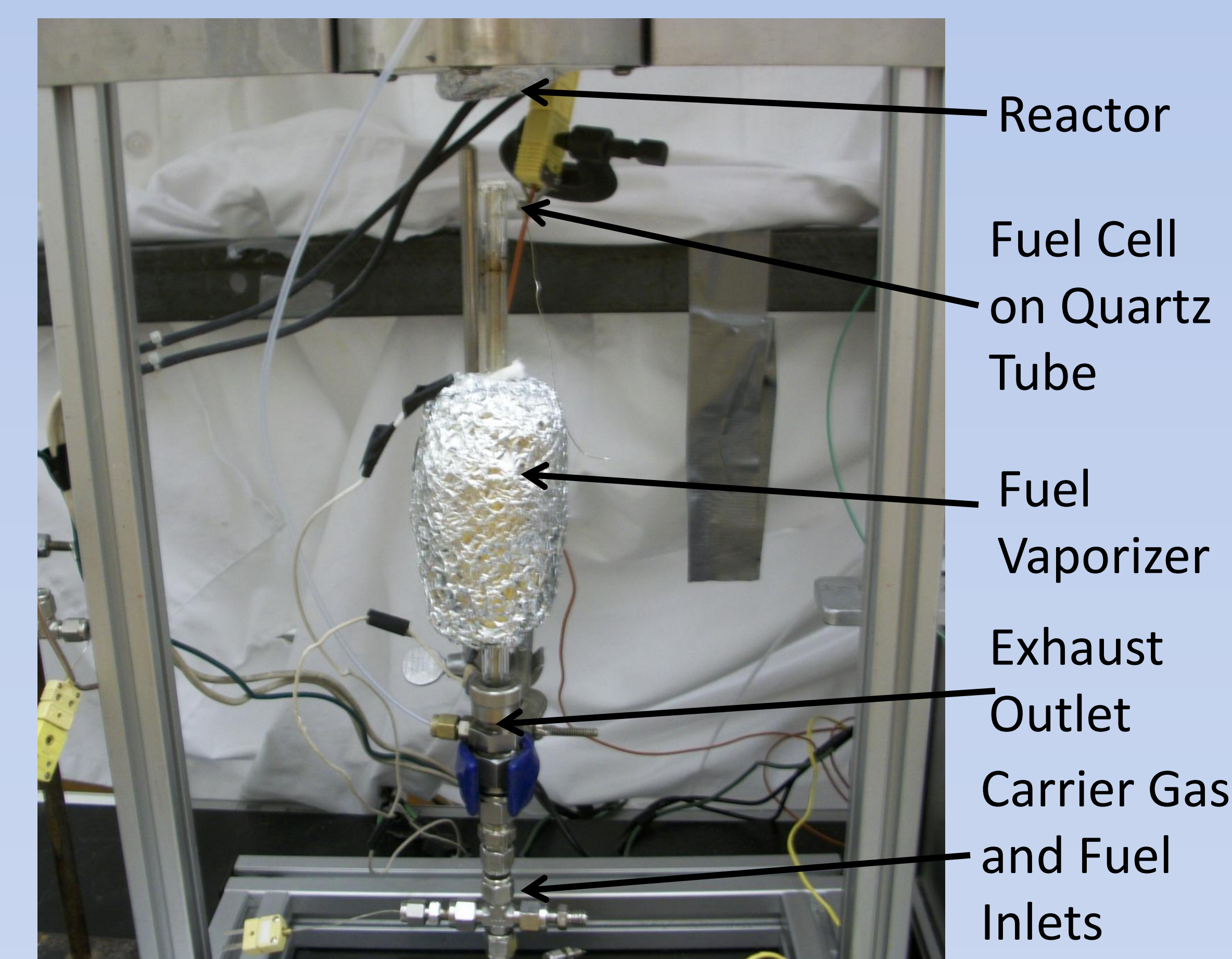
Stage 3: A carbon based fuel comes in contact with the anode which, in the presence of oxygen ions, catalyzes the reformation of the fuel into carbon dioxide and water. Electrons are given off in this reaction, setting up a voltage gradient between the anode and cathode which can be used to power electronic devices.



Methods

To test the SOFC, it was placed and sealed at the electrolyte on top of a quartz tube. Leads were first connected to both the anode and the cathode using silver conductive ink. The fuel cell was heated to an operating temperature of 800°C, and fuel was volatilized and pumped to the anode of the cell.

Apparatus



Results

Although a molybdenum dioxide based SOFC has yet to generate a quantitative amount of power, we have been able to produce stable anodes for a sustainable amount of time at the fuel cell operating temperature. This result shows promise for molybdenum dioxide SOFCs in the near future.

Future Work

Further research needs to be conducted to determine the optimal molybdenum dioxide to nickel ratio so that the anode retains stability at operating temperatures but does not allow poisoning from excess carbon or sulfur. It is expected that soon molybdenum dioxide based SOFCs will produce measurable power, so determination of the precise anodic composition will also need to be based on optimal power output.