Improving Fabrication of Solid Oxide Fuel Cells

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Background

Solid Oxide Fuel Cells (SOFCs) are devices that take in hydrogen and through an electrochemical reaction produce electricity with minimal emissions. They are comprised of an anode, cathode, and electrolyte. These cells are made of ceramic materials, so they operate between 600-1000°C in order to achieve sufficient ionic conductivity [1].

Objectives

- Test silver as an external current collector for the anode
  - Collecting current externally requires a portion of the anode to be exposed, which could allow fuel to escape and cause damage to the cell [2]
- Understand the kinetics and reactions occuring if hydrocarbons are to be used as fuel for SOFCs.
  - Hydrogen is the optimal fuel but there are issue with storage [3]
  - Hydrogen is current produced by reforming hydrocarbons

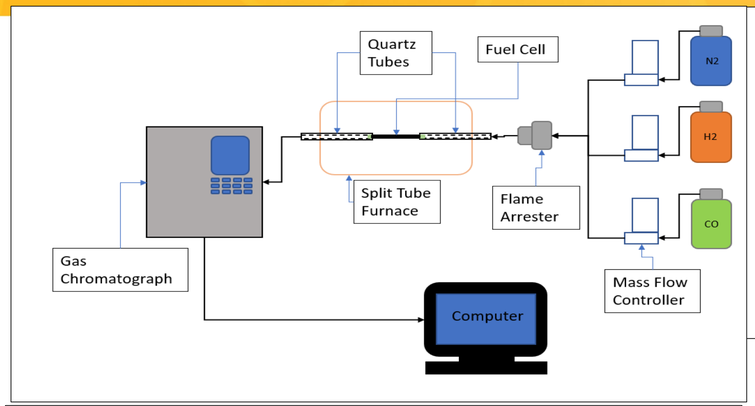

Figure 2: Experimental Setup, all gasses were supplied at a rate of 10 mL/min

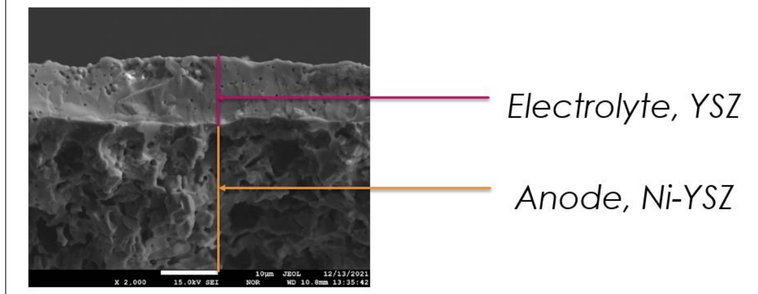

Figure 1: SEM image taken of the bottom of the cell at 100 mL/min dip speed

Methods

- Fuel cells were fabricated using a dip coating technique
  - In figure 1, the thickness of the anode and electrolyte can be seen.
- Silver was applied to the cathode creating an active area of 4cm^2 and to the anode.
- In figure 2, hydrogen and carbon monoxide are being fed to the cell to simulate if hydrocarbons were to be used
  - Nitrogen was additionally supplied to act as a baseline

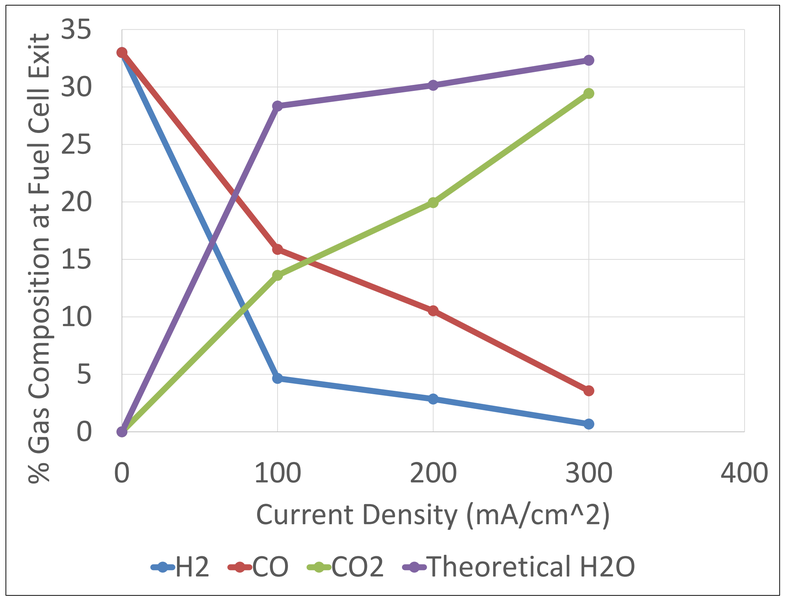

Figure 3: Gas Chromatograph results

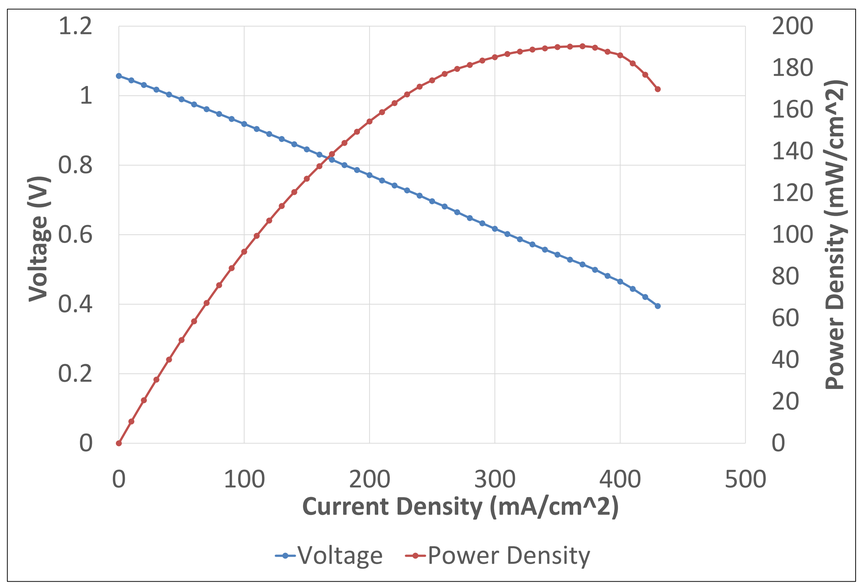

Figure 4: Polarization Curve

Discussion

- In figure 3 the hydrogen is disappearing at a significantly faster rate than the carbon monoxide.
  - This is expected because the kinetics are much faster for hydrogen in SOFCs.
- In the figure 4 at a voltage of 0.6 V, the power density is 190 mW/cm^2 is achieved.
  - In previous research, Dr. Milcarek has applied gold as a current collector to the anode. He had a total active area of 15.03cm^2 and was able to achieve about 440 mW/cm^2 per cell at a voltage of 0.6V [4].
  - This is double the power density achieved in figure 4 but hydrogen flow rate he used was 20 times larger. This makes silver a promising material for anode current collection

References: [1] O'Hayre R, Cha S-W, Colella WG, Prinz FB. Fuel cell fundamentals. In: Fuel Cell Fundamentals. Third. Hoboken, NJ: John Wiley & Sons, Inc.; 2016. p. 1–580.
[2] Hodjati-Pugh O, Dhir A, Steinberger-Wilckens R. The development of current collection in micro-tubular solid oxide fuel cells—a review. Appl Sci. 2021;11(3):1–27.
[3] Mohammed H, Al-Othman A, Nancarrow P, Tawalbeh M, El Haj Assad M. Direct hydrocarbon fuel cells: A promising technology for improving energy efficiency. Energy [Internet]. 2019;172:207–19. Available from: https://doi.org/10.1016/j.energy.2019.01.105
[4] Milcarek RJ, Garrett MJ, Ahn J. Micro-tubular flame-assisted fuel cell stacks. Int J Hydrogen Energy [Internet]. 2016;41(46):21489–96. Available from: http://dx.doi.org/10.1016/j.ijhydene.2016.09.005

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