Solid oxide fuel cells (SOFCs) are devices that convert chemical energy into electrical energy and have the potential to become a reliable renewable energy source that can be used on a large scale. SOFCs have 3 main components: the electrolyte, the anode, and the cathode. Typically, SOFCs work by reducing oxygen at the cathode into $O_2^-$ ions which are then transported via the electrolyte to the anode to combine with a fuel such as hydrogen to produce electricity. Research into better materials and manufacturing methods is necessary to reduce costs and improve efficiency to make the technology commercially viable.

The goal of the research is to optimize and simplify the production of single SOFCs using high performance ceramics. This includes the use of 8mol% Y2O3-ZrO2 (YSZ) and 10mol% Sc2O3-1mol%CeO2-ZrO2 (SCSZ) layered electrolytes which purport higher conductivity than traditional pure YSZ electrolytes. Prior to printing the electrodes onto the electrolyte, the cathode side of the electrolyte was coated with 20mol% Gd2O3-CeO2 (GDC). The GDC coating prevents the formation of a nonconductive La2Zr2O7 pyrochlore layer, which forms due to the interdiffusion of the YSZ electrolyte ceramic and the (La0.6Sr0.4)0.995Fe0.8Co0.2O3 (LSCF) cathode ceramic during sintering. The GDC layer was deposited by spin coating a suspension of 10wt% GDC in ethanol onto the electrolyte. Variation of parameters such as time, speed, and ramp rate were tested. Deposition of the electrodes onto the electrolyte surface was done by screen printing. Ink was produced using a three roll mill from a mixture of ceramic electrode powder, terpineol, and a pore former. The pore former was selected based on its ability to form a uniform well-connected pore matrix within the anode samples that were pressed and sintered. Ink development involved the production of different ratios of powder-to-terpineol inks to vary the viscosity. The different inks were used to print electrodes onto the electrolytes to gauge print quality and consistency. Cells were produced with varying numbers of layers of prints to achieve a desirable thickness. Finally, the densification behaviors of the major materials used to produce the single cells were studied to determine the temperatures at which each component needs to be sintered to achieve the desired density and to determine the order of electrode application, so as to avoid over-densification of the electrodes. Complete cells were tested at the National Energy Technology Laboratory in Morgantown, WV. Cells were tested in a custom-built test stand under constant voltage at 800°C with 3% humidified hydrogen as the fuel. Both voltage-current response and impedance spectroscopy tests were conducted after initial startup and after 20 hours of operation. Impedance tests were performed at open circuit voltage and under varying loads in order to analyze the sources of resistance within the cell. A general increase in impedance was found after the 20h operation. Scanning electron micrographs of the cell microstructures found delamination and other defects which reduce performance. Suggestions for eradicating these issues and improving performance have been made.