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Characterization of Anode Nickel Coarsening in Solid Oxide Fuel Cells through Impedance Spectroscopy

Solid Oxide Fuel Cells (SOFCs) are an energy production technology which offer the possibility of achieving very high efficiencies in converting fuel sources to electrical energy. The general design of SOFCs consists of a triple-layered structure consisting of anode and cathode outer layers and a center electrolyte. The principal anode material used in oxygen-ion-conducting SOFCs is a porous cermet of nickel and yttria-stabilized zirconia (Ni-YSZ). The anode is the site of fuel oxidation, and an even distribution of nickel grains, YSZ particles, and open pores is desired for optimal performance. Oxygen-ion-conducting SOFCs operate at high temperatures (500° C-1000° C), which results in amalgamation of the nickel grains over time (Coarsening), reducing power output. This is the major limitation on SOFC lifespan, and mitigating the coarsening process would significantly increase the economic viability of SOFCs. Understanding coarsening is a necessary step in mitigation. Impedance spectroscopy is an observational technique which allows the time growth of nickel grains to be accurately characterized. The dielectric properties of the anode are measured as a function of frequency. The high conductivity of the nickel causes the sample to have low impedance relative to the apparatus, and therefore pellets of anode material with varied nickel volume percentages (10%-30%) will be manufactured so that the nickel percolation threshold may be found. Near and below this threshold the sample impedance will rise sharply, allowing inspection with the impedance apparatus. The pellets will be held at high temperature in the impedance apparatus, so that the dependence of nickel coarsening on time, temperature, and anode composition may be characterized. The findings will increase understanding of the coarsening process and may be incorporated into the design of future SOFCs.