DIRECT OXIDATION AS A MARKET ENABLER FOR SOLID OXIDE FUEL CELLS

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Fuel cells elude mass commercialization for many well-known factors. Chief among these is the difficulty in establishing a supply infrastructure for hydrogen, the fuel cell's fuel of choice, without evidence of a significant demand for hydrogen from an existing fuel cell fleet and a consumer market unwilling to accept fuel cells without an existing hydrogen supply network. The availability of fuel flexible fuel cell devices, ones capable of operating on readily available fuels such as natural gas, gasoline or diesel, can help bridge this gap between supply and demand, enabling fuel cells to penetrate markets unlikely to have access to hydrogen for many years.

The direct oxidation technology developed at the University of Pennsylvania for solid oxide fuel cells (SOFCs) is one that enables the SOFC to oxidize dry hydrocarbon fuels directly in the anode without any fuel reforming. This technology has been licensed exclusively by Franklin Fuel Cells, Inc. of Wayne, Pennsylvania, for the purpose of commercializing SOFC stacks capable of operating on a variety of fuels. The technology employs a composite anode of Cu, CeO_2 and yttria-stabilized zirconia (YSZ). Conventional SOFCs utilize a composite of Ni and YSZ in the anode. Although Ni has been shown to be an excellent catalyst for the oxidation of hydrogen and has good electrical conductivity, its presence does not allow for the use of dry hydrocarbon fuels. Above 600°C, Ni catalyzes the formation of graphite from dry hydrocarbons, which can quickly deactivate the cell due to carbon deposition. On the other hand, Cu is an excellent electronic conductor and will not form carbon deposits in the presence of dry hydrocarbons. Ceria is added to the anode because of its high activity for hydrocarbon oxidation and high ionic conductivity.

Single cells utilizing the Cu/CeO_2/YSZ anode, a dense 60µm YSZ electrolyte and a 50/50 YSZ/LSM cathode have demonstrated performance at 700°C of 0.150 to 0.250 W/cm^2 with dry hydrocarbon as well as pure hydrogen for fuel. These cells have also shown stable power generation using hydrocarbon fuels having sulfur levels similar to that in gasoline.

With no need for external, or internal, fuel reforming, simpler fuel conditioning, if at all, no precious metals and utilizing high yield, low cost manufacturing methods, this proprietary technology has the potential to dramatically simplify the fuel cell system, radically reducing its cost, all while improving efficiency. Fuel flexibility, lower \$/kW, and a simpler, more reliable system design mean less time to market. In this paper, we describe the development effort underway at Franklin Fuel Cells Inc. in the area of direct oxidation SOFC stacks and the potential for this technology to propel SOFC product commercialization.