An Integrated Microfluidic Fuel Cell System for Energy Conversion from Hydrocarbon Fuels

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Abstract

The architecture, fabrication and assembly of a fuel cell system will be described which enables effective scaling of the fuel delivery, fuel processing, manifold, and fuel cell stack components for applications in miniature power sources or energy conversion devices for microanalytical systems. The approach described utilizes micromachining techniques to simultaneously form gas diffusion electrode supports and microfluidic manifolding in a common silicon substrate for the fuel cell, which can either be a proton exchange membrane (PEM) or solid oxide fuel cell (SOFC). Integrated resistive heaters are used for maintaining the thermal requirements for device startup with a backup power source. Wafer bonding creates a sealed microfluidic network for distributing fuel, while catalytic fuel reforming converts methanol and water fuel mixtures of 1:1 mole ratio to hydrogen and other byproducts.

Electrode materials for fuel cells have been developed using sputter deposition techniques. Control of deposition parameters effectively forms a continuous coating over the gas diffusion support with a conductive, porous thin film structure. Ion or proton conducting electrolytes are formed using either sputter deposition (SOFCs) or spin-cast methods (PEM) to create a thin film electrolyte. Subsequent deposition of a porous thin film allows an air breathing cathode. For solid oxide electrolytes, tailoring of the specific electrolyte material will effectively lower the temperature of operation for the fuel cell stack to a range which is suitable for miniaturization. Further integration of a catalytic fuel processing device incorporates high surface area catalyst into either a packed bed or porous membrane configuration allowing direct coupling to the fuel cell manifold.

The above components which will be described in this paper represent the core of this miniature energy conversion device. Results to be presented include fuel conversion efficiency for the fuel processor, operating temperature and thermal management issues, fuel cell performance, and integration issues for the entire system.

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