ABSTRACT
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Development and characterization of a miniaturized PEM fuel-cell for MEMS

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Abstract

In order to create autonomous mechatronics systems enabled with advanced MEMS sensors and actuators, long lasting, small, and efficient power sources are needed. Micro-proton exchange membrane fuel-cells (PEMFCs) have the potential to define such power sources due to their relatively high chemical to electrical energy conversion efficiency.

This paper presents results of our investigations on the effects of miniaturization of PEMFCs for use in MEMS. We developed analytical and computational models to determine the performance of scaled PEMFCs. These models use the Maxwell-Stefan equations, Darcy's Law, Ohm's Law, and Tafel's equation to account for species transport and diffusion, current distribution, and other governing phenomena. It was found that miniaturization of PEMFCs can increase their efficiency because of the dominance of surface area to volume ratio effects. Furthermore, miniaturization decreases ohmic losses due to reduction of the effective electrical path length, increases flux of the reactants due to decrease in gas diffusion layer thickness, and helps increases the effective pressure.

Using the results of our analytical and computational models, the dimensions of similarly designed PEMFCs having a power output on the order of 1.8 mW, suitable to drive a MEMS accelerometer, were obtained. PEMFCs were constructed, characterized, and their performance compared with analytical and computational results. Coupled with sufficient background investigation, the results culminate in a recommendation for fabrication of micro-PEMFCS.

Keywords: MEMS, Fuel-cells, Computational modeling, Miniaturization