Exploration of Novel MEA Structures in a Silicon-based Formic Acid Microfuel Cell

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Micro fuel cells are expected to find applications in all kinds of portable devices like cell phones, laptops etc. Recent work has shown that miniaturized Proton Exchange Membrane Fuel Cells (PEMFC) deliver power densities comparable to those of similar large scale fuel cells.[1] Here we report the fabrication and characterization of silicon-based microfuel cells that are operated in either a forced liquid feed or a passive vapor feed mode.

Silicon-based membrane electrode assemblies (MEAs) were prepared using various microfabrication processes. Briefly, a double-sided <100> oriented polished wafer was covered on the front side with a Au layer which acts as a current collector. A polyimide layer acts as a separator. The catalyst layer was then deposited electrochemically. Two such grids were bonded to a Nafion 112 membrane to yield a silicon-based MEA as shown in Figure 1. A detailed description on the fabrication of the silicon-MEA is described elsewhere.[2]

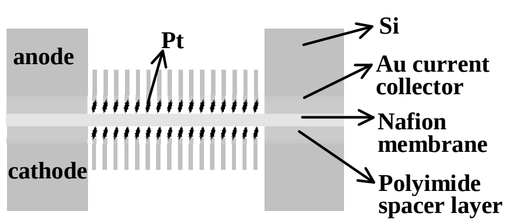

Figure 1. Schematic diagram of silicon-based MEA.

In this presentation we will compare the characteristics of our silicon-based MEAs with those of conventional gas diffusion layer based MEAs. Some key advantages of our Si-grid based designs are: (i) The current collector, flow field and catalyst are integrated on a single chip, and (ii) the grid structure facilitates mass transport of the reactants and the products.

We typically use formic acid as the fuel in our microfuel cell experiments. Formic acid recently has been introduced as an alternative fuel, because it has certain advantages over methanol: (i) higher reaction kinetics at room temperature resulting in higher power densities at ambient temperatures, (ii) reduced crossover problems at room temperature, and (iii) reduced CO poisoning of the catalyst.[3]

In PEMFCs, fuel can be delivered either in a liquid or gaseous form. The need for an actively controlled pumping mechanism for liquid fuel delivery contributes to the parasitic losses. In our vapor-feed formic acid fuel cell, fuel is stored in a liquid form and delivered to the MEA by natural evaporation. We will present the performance of Si-based microfuel cells with forced liquid feed and passive vapor feed.

(1) *Forced feed*: Fig. 2 shows the performance of silicon-based fuel cells operating under forced feed conditions. These cells produce a current density of 50 mA/cm^2 at a cell potential of 0.3 V. A peak power density of 17 mW/cm2 was achieved at a cell potential of 0.25 V.

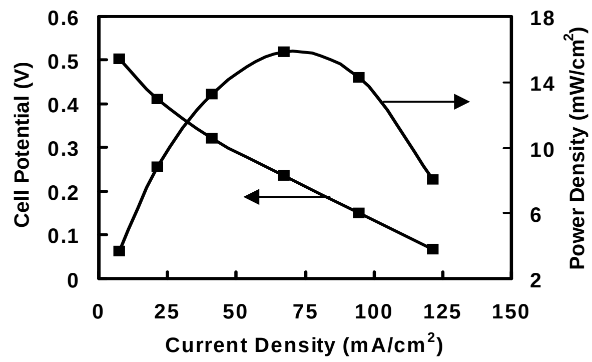

Figure 2. IV and power density data curves for silicon-based microfuel cell with formic acid as a fuel under forced feed conditions. Anode side: 10 M formic acid at a flow rate of 0.5 ml/min, Cathode side: oxygen with a flow rate of 90 ml/min.

(2) *Vapor feed*: Scanning electron micrographs of the evaporative structure used to supply formic acid to the anode is shown in Fig. 3. These high surface area structures ensure sufficient fuel delivery to the anode. As expected, the power densities obtained for this type of cells were lower, about 2 mW/cm^2, than those obtained for forced feed cells. However, further optimization of these cells is in progress.

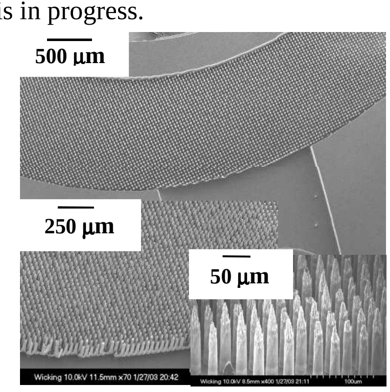

Figure 3. Scanning Electron Micrograph of silicon based evaporative structure

In summary, this paper will describe fabrication and characterization of a direct formic acid microfuel cell operating under forced feed or passive vapor feed. A vapor feed fuel cell with fuel delivery through natural evaporation eliminates the need of ancillary components, and thus avoiding parasitic losses. The characteristics of microfuel cells based on our novel grid-like MEA structures will be compared to the characteristics of fuel cells with more conventional GDL-based MEAs.

Acknowledgements

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