Thin Film Thermal Sensor for
Polymer Electrolyte Fuel Cells

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Temperature measurement of an operating polymer electrolyte fuel cell (PEFC) is critical to the research on cold start, water balance and degradation. This presentation will describe development of a novel type of thin film thermal sensor for application in an operating PEFC. The sensor set is less than 10 μm thick and is fabricated using micro-machining technologies, such as e-beam evaporation and chemical vapor deposition.

Researchers have been engaged in real time temperature measurement in a fuel cell for a while. A review of various methods for achieving temperature distribution measurement is given by Wang *et al.* [1], including infrared technology. Vie and Kjelstrun[2] placed a millimeter sized thermocouple at various locations on the membrane electrolyte assembly (MEA). Mench *et al.*[3] laminated eight 50 μm thermocouples directly into two Nafion® 111 membranes.

In order to get higher spatial resolution and good sensitivity, further improvement on the sensor requires application of micro-machining technologies. A thin film thermal sensor has been developed for this purpose. Debey *et al.*[4] fabricated thin film thermocouple with 10 measuring points in 2 mm. Debey used polymide and ceramics as substrate. However, the substrate for PEFC application is Nafion®, which has a linear expansion of 10% from 50% relative humidity, 23°C to water soaked, 23°C. Therefore, one critical challenge is to design a sensor that will withstand the stretching force during electrolyte membrane water uptake.

This presentation will present the fabrication process and the performance of the thin film sensor. The sensor can now survive from the electrolyte expansion forces and is robust. Calibration results show that the sensor has a highly linear response over temperature. Moreover, the thin film sensor has the potential to be further minimized using photolithography and etch technologies.

Figure 1 is a plot of the layouts of the sensor design. The 1st design uses thermistor and thermopiles. The thermistor measures the cold junction temperature of the thermopiles, while the hot junctions of the thermopiles stick into the flow channel. The 2nd design uses thermistors to directly measure the respective temperature of the inlet and outlet of the PEFC electrolyte. The dashed flow channels are taken from a $5 cm^2$ PEFC and the shadowed areas are covered by parylene. Figure 2 is a plot of the thermistor resistance versus temperature during calibration at different operation periods. The curves show that the resistance has highly linear dependence on temperature and the slope remains constant even after long periods.

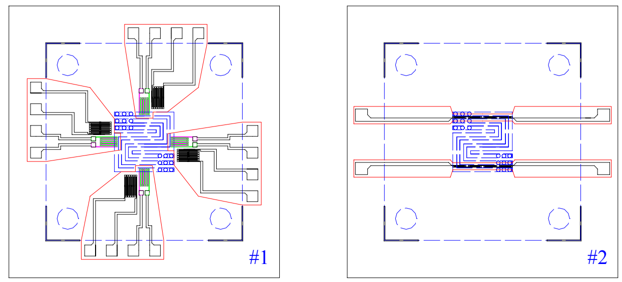

Figure 1: Thermo sensor design.

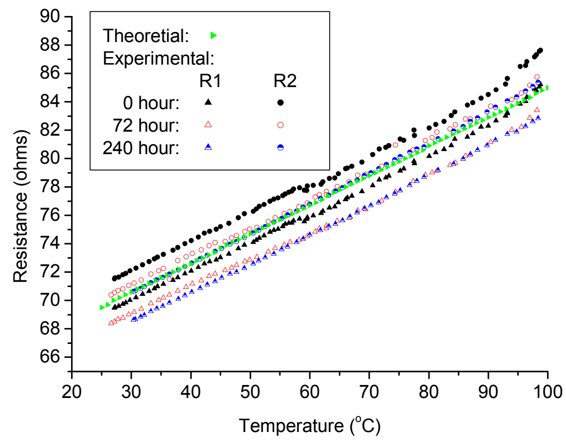

Figure 2: Plot of thermistor resistance versus temperature during calibration at different operation periods.

1) M. H. Wang, H. Guo, C. F. Ma, F. Ye, J. Yu, X. Liu, Y. Wang, and C. Y. Wang, *Proc. 1st Inter. Fuel Cell Sci.*, pp. 95-100 (2003).
2) P. J. S. Vie and S. Kjelstrup, *Electrochimica Acta*, vol. 49, No. 7, pp. 1069-1077 (2004).
3) M. M. Mench, D. J. Burford, and T. W. Davis, *ASME, Heat Transfer Division*., Vol. 374, No. 2, pp. 415-428 (2003).
4) D. Debey, R. Bluhm, N. Habets, and H. Kurz, *Sensors and Actuators, A: Physical*, Vol. 58, No. 3, pp. 179-184 (1997).