

## Development of Stand-Alone Portable Direct Methanol Fuel Cell System

T. Shimizu<sup>a,b</sup>, T. Momma<sup>a,b</sup>, M. Mohamedi<sup>a</sup>, T. Osaka<sup>a</sup> and S. Sarangapani<sup>c</sup>

<sup>a</sup>Graduate School of Science and Engineering, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555, Japan

<sup>b</sup>CREST, Japan Science and Technology Agency

<sup>c</sup>ICET, Inc., 916 Pleasant Street, Unit 12, Norwood MA 02062, USA

For many applications that have been proposed for small-scale fuel cells, it would be essential that they be stand-alone systems with no external pumps or other ancillary devices. Therefore, air-breathing fuel cells, *i.e.*, cells that take the oxygen directly from the surrounding air, may offer advantageous properties, because there is no need of auxiliary air circulation devices.

Here, we report on some of our recent progresses regarding the research and development of completely passive room temperature operation small DMFCs power sources. These systems are intended for portable electronics such as laptop computers, PDA devices, and cellular phones.

A number of technical issues were addressed and experimented before achieving our target. Several design parameters were decided by paying attention to the following points:

-*Current collector.* We have tested two types of current collector. One was a perforated stainless steel (SUS mesh) sheet of 0.5 mm thickness with an open area of 20 % used on both anode and cathode sides. The other current collector was a gold-plated SUS mesh (SUS/Au). Comparative runs with these two type of CCs on a test cell demonstrated that with the gold-plated SUS as current collector the passive DMFC performance greatly increased, *i.e.*, the maximum power density nearly doubled, the maximum usable current density increased, and the open cell voltage in the kinetics region augmented by 50 mV. Use of gold eliminates any contact resistance at the current-collector electrode interface.

-*Membrane electrolyte.* The methanol crossover rate is reported to be dependent on the thickness of the polymer membrane. Jung *et al.* demonstrated that Nafion 112 is poor in methanol permeability and Nafion 117 is better.<sup>1</sup> Therefore, the thicker membrane is, the less the methanol crossover becomes. However, with thick membrane, the power density of the cell will be reduced owing to its high ohmic loss, trading off with the low methanol crossover. Nevertheless, for our small DMFC at low current densities membrane resistance is not a factor.

-*Electrode Catalysts.* We have tried two types of catalysts: the carbon supported catalysts, and the blacks (*i.e.*, unsupported) catalysts. We found that that our DMFC performance is better with unsupported catalysts than with supported catalysts.

-*Compressive load.* In order to understand the effect of compressive load on the cell better, impedance measurements were carried out only at open circuit conditions. The results showed that the cell without compressive load had very high resistance. With some compressive load, the same cell showed lower resistance.

Figure 1 summarizes the individual performance of three 36 cm<sup>2</sup> area DMFC cells run at room temperature with 2.0 M of methanol, and air passive. The cells differed from each other either in the design or in the MEA fabrication. The voltage-current measurements were

started after the methanol solution was poured in the cell for 30 minutes. Each data point represents typical steady-state voltages that were taken after continuous operation for 3 min at the indicated current density. As can be seen a maximum peak power density as high as 8 mW/cm<sup>2</sup> was reached with 2 M methanol at current densities of 25 mA/cm<sup>2</sup> and at a voltage of 0.3 V.

In addition, Cell III was further tested with up to 4.0 M of methanol concentration (data not shown here). The results showed that 3 M methanol gave the best performance, with 4 M yielding almost comparable results. A maximum peak power density as high as 11 mW/cm<sup>2</sup> was reached with 4 M methanol at current densities higher than 30 mA/cm<sup>2</sup> and at a voltage of 0.3 V.

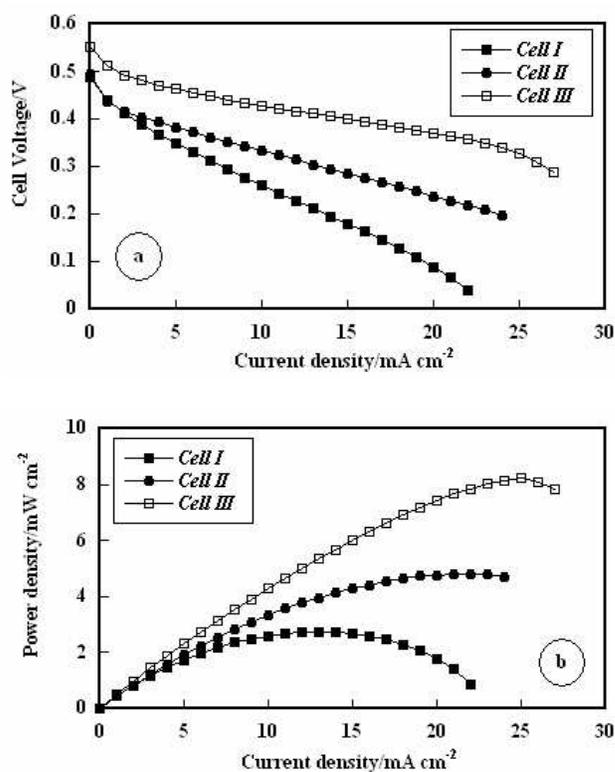
Additional work on downsizing the DMFC area was also performed. Details regarding cell design, fabrication and MEA preparation will be reported at the meeting.

## Acknowledgements

The present work was partly supported by Grants-in-aid for Scientific Research on Priority Area (B) (No. 13134204 for "New Technologies of DMFC"), COE Research "Molecular Nano-Engineering" and 21 COE Program "Practical Nano-Chemistry" from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan.

## References

1. D. H. Jung, C. H. Lee, C. S. Kim, D. R. Shin, *J. Power Sources*, **71**, 169 (1998).



**Figure 1** Performance of 36 cm<sup>2</sup> area passive DMFC. (a) Polarization, and (b) power density curves. Measurements performed with cells using SUS/Au current collector, 2.0 M methanol solution, ambient air, and room temperature. *Cell I* and *Cell II*: PtRu/C anode (4.1 mg/cm<sup>2</sup> of PtRu), Pt/C cathode (2.5 mg/cm<sup>2</sup> of Pt), Nafion 112. *Cell III*: unsupported Pt/Ru anode (6.4 mg/cm<sup>2</sup> of PtRu), unsupported Pt cathode (3.9 mg/cm<sup>2</sup> of Pt), and Nafion 117.