Two reaction-specific electrodes fabricated with the same process for the use in tissue implantable glucose fuelcells

Christian Köhler, Arne Kloke, Sven Kerzenmacher,
Roland Zengerle, Felix von Stetten

Laboratory for MEMS Applications, Department of Microsystems Engineering - IMTEK, University of Freiburg (Germany)

Abiotically catalyzed glucose fuel cells (GFCs) represent a promising approach for a self-sufficient power supply of low power implants from the electrochemical conversion of glucose and oxygen simultaneously present in tissue fluids [1].

Cathode: $\frac{1}{2} O_2 + 2 H^+ + 2 e^- \rightarrow H_2O$

Anode: $C_6H_{12}O_6 + H_2O \rightarrow C_6H_{12}O_7 + 2 H^+ + 2 e^-$

Such systems require two reaction-specific electrodes to achieve a reasonably high cell voltage. This is because both electrodes are operated in the same media and therefore a mixed electrode potential results from the two competing electrode reactions. Hence state of the art GFCs use two electrocatalysts differing in fabrication and material. Here we demonstrate the applicability of a novel catalyst deposition process to fabrication of both electrodes using the same material [2]. Pt-catalysts are fabricated from alternation of Pt-Cu co-deposition and Cu-dissolution.

With increasing number of deposition cycles and thus increasing surface roughness the electrodes show increasingly more negative open circuit potentials (OCP, see figure 1). Accordingly the electrode potentials follow a trend ranging from typical cathode potentials to typical anode potentials with up to 500 cycles.

This indicates that with increasing electrode area the kinetically controlled electrooxidation of glucose is preferred over the diffusion controlled reduction of oxygen. Accordingly a difference in OCP of 0.73 V results between electrodes fabricated with 1 and 500 deposition cycles. Correspondingly assembled fuel cells (cathode: 12 cycles, anode: 500 cycles) exhibit a maximum power density of 4.3 ± 0.2 µW cm^{-2} (see figure 2) which is comparable to state of the art GFCs using two different electrocatalysts (2.5 to 8.0 µW cm^{-2} under comparable conditions [1]).

We demonstrated a catalyst deposition process applicable to the fabrication of both electrodes in implantable GFCs leading to a significantly facilitated fabrication and at a power density comparable to state of the art. The electrodes' reaction-specificity is achieved by simply adjusting the number of deposition cycles.

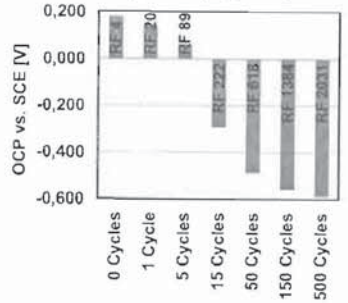

Fig. 1: OCPs recorded in PBS+glucose (3 mmol l^{-1}) at 37 °C and 0 % O_2-saturation. Surface area is indicated by RF (ratio between active and base area).

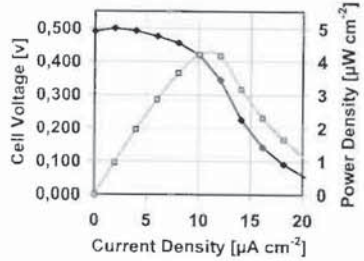

Fig. 2: Cell voltage and power density of fuel cells recorded in PBS+Glucose (3 mmol l^{-1}) at 37 °C and 7 % O_2-saturation.

References

[1] S. Kerzenmacher, J. Ducrée, R. Zengerle, F. von Stetten, *J. Power Sources*, **182** (2008) 1.

[2] A. Kloke, S. Kerzenmacher, R. Zengerle, F. von Stetten, "Facile Fabrication of Ultra Porous Platinum Electrodes ...", presented at *ECS 215th Meeting - San Francisco, CA* (2009).