

**Title:****A Permeable Foil-Based Thin Layer Oxygen Cathode  
for Biofuel Cell and Sensor Applications****Authors & affiliations:**

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**Abstract:** (Your abstract must use **Normal style** and must fit in this box. Your abstract should be no longer than 300 words. The box will 'expand' over 2 pages as you add text/diagrams into it.)

In fuel cell and sensor research foil-based electrodes offering high surface area are of special interest. Here we demonstrate the development of an oxygen cathode established on a polyimide track etch membrane. Furthermore this cathode is permeable and therefore especially interesting for applications desiring mass transport through the cathode. We developed this electrode for abiotically catalyzed glucose fuel cells which require a permeable oxygen cathode on top of a glucose anode to enable separate electrode reactions [1], but this approach is also interesting for enzymatic fuel cells and sensor technology.

Following a protocol similar to van der Wal et al. [2], we formed platinum alloys with aluminum (figure 1). Layers of 500 nm platinum and 500 nm aluminum were vapor-deposited on silicon. Samples were annealed at 300 °C for 120 minutes and subsequently activated in NaOH. We observed roughness factors comparable to van der Wal (about 150) using cyclic voltammetry (figure 2).

Operated in aerated phosphate buffered solution these electrodes showed their applicability as oxygen reduction cathodes even after adding glucose to the solution and lowering the oxygen concentration (figures 3, 4).

Using this process with 250 nm thick layers of platinum and aluminum on polyimide track etch membranes having straight pores of 2 µm in diameter we succeeded in developing thin (25 µm), permeable and flexible electrodes (figure 5). Their roughness factor is higher than 30.

As cathode the foil-based electrode polarizes less under load than the ones fabricated on silicon but show a slightly lower open circuit voltage (figure 4).

We showed the applicability of platinum-aluminum alloy formation for production of an oxygen cathode working under physiological concentrations of oxygen and glucose and succeeded in transferring this process onto a thin permeable foil substrate. Their electrochemical performance is comparable to carbon based oxygen cathodes which are state of the art in abiotically catalyzed glucose fuel cells (figure 3) [3].



Figure 1

Structural principle of the foil-based electrodes: The vapor-deposited layers of platinum and aluminum get annealed (300 °C, 120 minutes) and subsequently the aluminum not involved in alloy formation is etched away in NaOH.

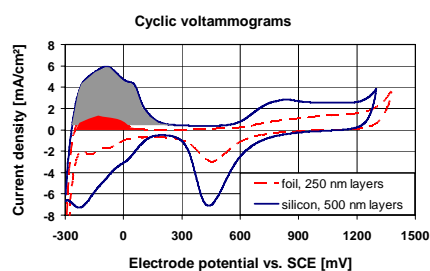


Figure 2

Cyclic voltammograms in 0.5 mmol l<sup>-1</sup> H<sub>2</sub>SO<sub>4</sub> in nitrogen atmosphere show the shape characteristic for platinum. The active surface area is calculated from the hydrogen desorption charge (shaded areas).

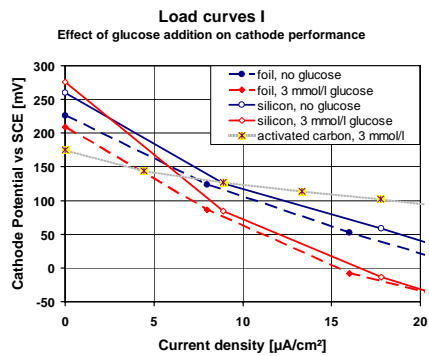


Figure 3  
In U-I-curves at 21 % oxygen saturation both new electrode approaches lead to a higher open circuit voltage but a slightly stronger polarization compared to a state of the art activated carbon cathode for abiotically catalyzed glucose fuel cells. Oxygen cathode characteristic is preserved after glucose addition in physiological concentration.

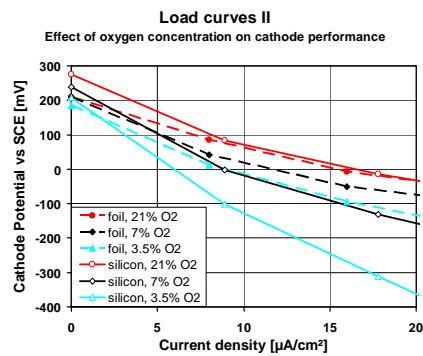


Figure 4  
Load curves of silicon and foil based electrodes at physiological oxygen saturation (3.5 – 7 %) in phosphate buffered 3 mmol l<sup>-1</sup> glucose solution. Foil electrodes show a decreased open circuit voltage but also a decreased polarization. Even at 3.5 % oxygen saturation the electrode potential is applicable for oxygen reduction in a glucose fuel cell.

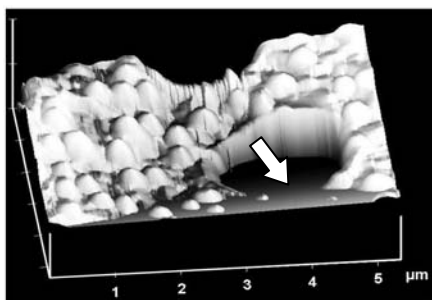


Figure 5  
This AFM image of a foil-based electrode shows a wavy surface with hilly features. The hole (see arrow) has a diameter of 2 μm complying with the pore diameter of the foil substrate.

#### References

1. Rao, J.R., Richter, G., von Sturm, F., Weidlich, E., 1973. Berichte der Bunsen-Gesellschaft-Physical Chemistry Chemical Physics 77 (10/11), 787-790.
2. van der Wal, P.D., Dadras, M., Koudelka-Hep, M., de Rooij, N.F., 2004. ECS Meeting Abstracts 602 (8), 495.
3. von Stetten, F., Kerzenmacher, S., Sumbharaju, R., Zengerle, R., Ducree, J., 2006. Proceedings of the Eurosensors XX Conference 2006, M2C-KN.

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