Microelectrode Arrays for Electroactive Species Detection in High Resistive Media

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Actual electrochemical sensors should be reliable and as versatile as possible. They should be able to make measurements in various media and in drastic conditions. From this point of view, microelectrode based sensors already developed since many years at CSEM provide unique solutions to many applications in electrochemical analysis that cannot be achieved with conventional electrodes (macroelectrodes). A well-known problem encountered with conventional electrodes is their lack of sensitivity toward electroactive species present in high resistive aqueous media. This problem is the consequence of the high ohmic drop near electrode interface. However, this problem can be overcome in using microelectrode-based sensors because, due to their geometrical characteristics and low ohmic drop, their response is almost independent of the media conductivity.

Measurements of silver (Ag^+) traces by anodic stripping voltammetry (ASV) in high and low resistive aqueous media are performed with a three-electrode cell in a Faraday cage to avoid external noise. The working electrode (WE) is a microelectrode consisting of a hexagonal array containing 200 carbon "holes", 5 µm in diameter and separated by 100 µm [1], or a surrounding carbon disk macroelectrode 2 mm in diameter.

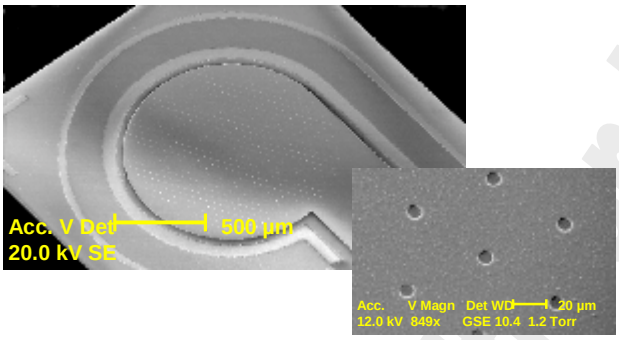

Figure 1
Micro-Disk Electrodes

The reference electrode (RE) is an Ag/Ag Cl/KCl 3M protected by an additional bridge of KNO_3 3M to avoid contamination with Cl^- ions, or a Pt wire. The counter electrode is a Pt wire.

Results illustrated by Figures 2 and 3, show that:

- The response of a microelectrode is not influenced by conductivity of the media between 0,5 µScm^{-1} and 20 mScm^{-1}.
- Contrary to macroelectrode (> 50 µm in diameter), geometrical characteristics of the microelectrode drastically diminish the ohmic drop. Otherwise the diffusion characteristics near the microdisk make the ionic strength to be higher in the proximity of the electrode. This phenomenon seems to enhance nucleation of metal during deposition period.

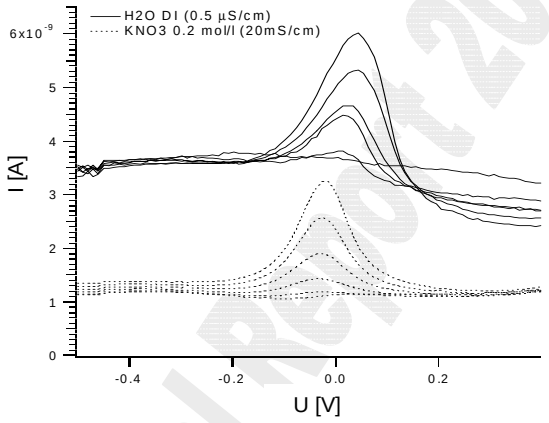

Figure 2
Response of a microelectrode in various resistive water media with different silver (Ag^+) concentrations (10; 20; 30; 40; 50 µg/L)

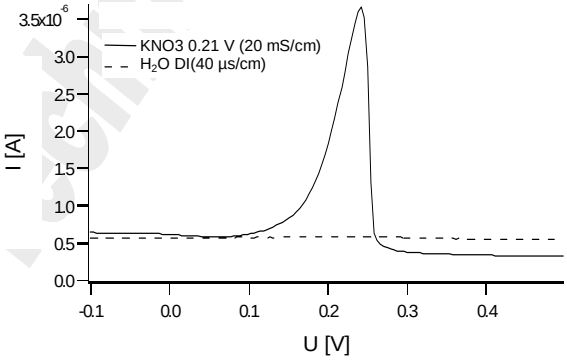

Figure 3
Response curves showing the lack of sensitivity of a carbon disk macroelectrode in low conductive media

Microdisk array electrodes are extremely well suited for electroactive species detection in low conductive media such as purified deionised water for pharmaceutical and microelectronic industries.

This work points up a new set of ASV applications, which until now have not been feasible with conventional or macroelectrodes.

[1] X.M. Tang, N. Skinner, G.C. Fiaccabrino, M. Koudelka-Hep, "Chemical Analyses Using Microstructured Thin-Film Amorphous Conducting Carbon", ECS Meeting Abstracts, MA96-2(1996) 895