

Digitizing gold porous electrodes using FIB-SEM analysis

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Abstract : This project is dedicated to a bottom-up approach to optimize the design of porous electrode materials devoted to biofuel cells and biosensors. These devices operate on the basis of complex enzymatic electrochemical redox reactions coupled to mass transfer of substrates (glucose and O₂) and electron transfer within the pores of the structure and from/to the pore surfaces. The advantage of using porous materials for these devices lies in the very large internal surface area (where electron exchange takes place) to overall material volume ratio, yielding much larger current densities than on a bare solid electrode of the same size. Some very interesting techniques, based on templating silica beads on gold substrate with a Langmuir-Blodgett deposition¹ step followed by electroplating of gold² and beads dissolution have been elaborated to synthesize porous materials made of pure gold having a typical spherical pore size of the order of the micrometer. The objective of the project is to model the porous structure of the electrode. First, a determination of the geometrical characteristics can be achieved through image acquisition and analysis. The structure not only contains a gradient of hollow spherical pore radii, but also some degree of disorder due to local arrangement defects; the radii of the windows separating the pores is also locally variable. Since pore window dimensions are around 100 nm, Focused Ion Beam-Scanning Electron Microscopy (FIB-SEM³) (**Fig. 1**) has been performed to obtain a 3D reconstruction of the porous medium. Segmentation and binarization of images were made both manually and automatically using Fiji and Python. More than 600 SEM (SE) images (25 nm between 2 images) yield a 3D image of a part of the electrode (**Fig. 2**). The shape of the connections between spheres, the distances between spheres and the sphere diameters have been analysed.

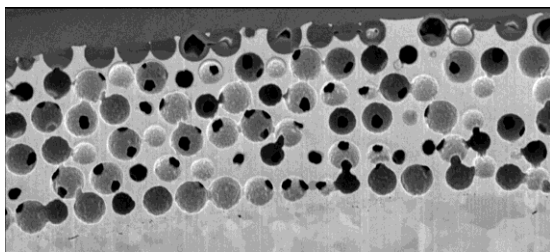


Fig. 1 : example of FIB-SEM image of the porous gold electrode

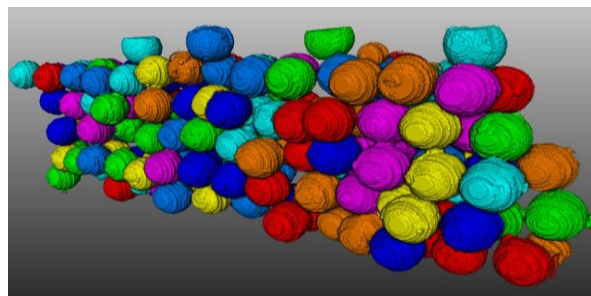


Fig. 2 : 3D reconstruction of the void space of a part of the porous medium

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