

Advanced Electrodes with Nanostructured Surfaces for Electrochemical Microsensors

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Nanostructures have recently attracted great interest because of their unique properties and potential use in a broad range of technological applications. In the case of microsensors, an array of nanostructures can be used to enlarge the surface area of sensing electrodes. It is assumed that microsensors will then have higher sensitivity due to the surface modification.

One of the simplest ways to modify an electrode surface by nanostructures is to deposit a metal into a thin nanoporous Al_2O_3 template which covers a gold electrode. Metal ions are attracted to the cathode (the gold electrode) during electrodeposition and fill the nanoporous template. After finishing the electrodeposition process, the template is dissolved and the metal nanostructures are obtained. The process of creating nanostructures is illustrated in *Fig. 1*.

The Al_2O_3 template is produced by anodic oxidation of a thin layer of very pure aluminium. The aluminium layer can be deposited either by sputtering or vapour deposition. However, vapour deposition is more suitable for template preparation because the deposited layer contains only small crystals of aluminium and is uniform [1].

Diameters and density of nanostructures are determined by the template. The length of the nanostructures depends on the amount of the metal which is deposited into the template. The weight of the metal is usually directly proportional to the current density and the duration of deposition. However, in the case of nanopores with high aspect ratios (length to diameter), mass transport is limited only to diffusion [2].

The electrolyte, used for the majority of the experiments on the nanostructure growth, was Watts Bath (containing 250 g/l of NiSO_4 , 50 g/l of NiCl_2 , and 34 g/l of H_3BO_3). The nanostructures were created under various electroplating conditions, such as the use of ultrasound waves, a wide range of current densities, various concentrations, various diameters of the nanopores, etc. In the case of the latest experiments, standard stirring of the solution has been replaced by a new local deposition method in which only a small volume of an electrolyte is employed.

Both nanowires (*Fig. 2*) and nanotubes (*Fig. 3*) of various wall-thicknesses can be created by this method. It has been found that the type of the structure depends on specific electroplating conditions (e.g. the pH and the concentration) and used template (i.e. the diameters of the nanopores). Therefore, it is possible to control the type of the nanostructure by adjusting these electroplating parameters and to create either nanotubes or nanowires purposely.

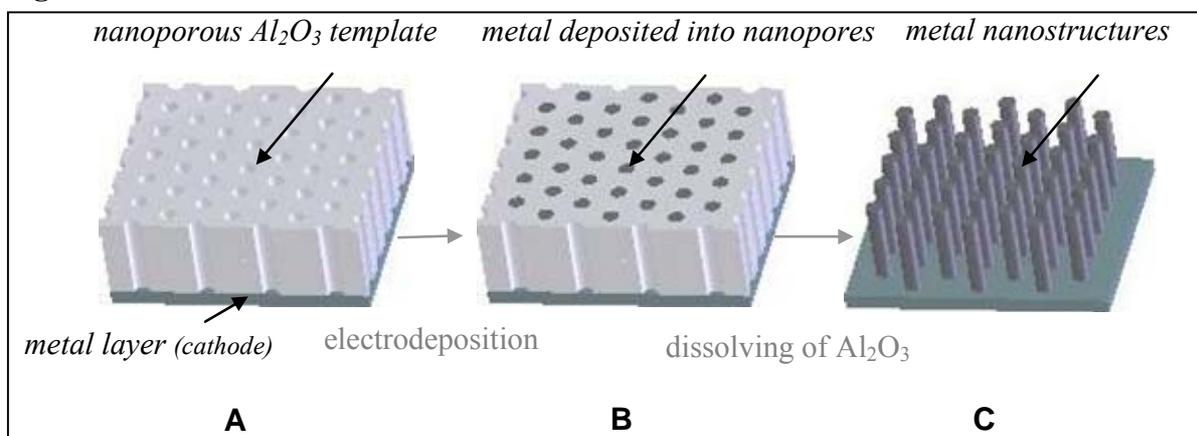
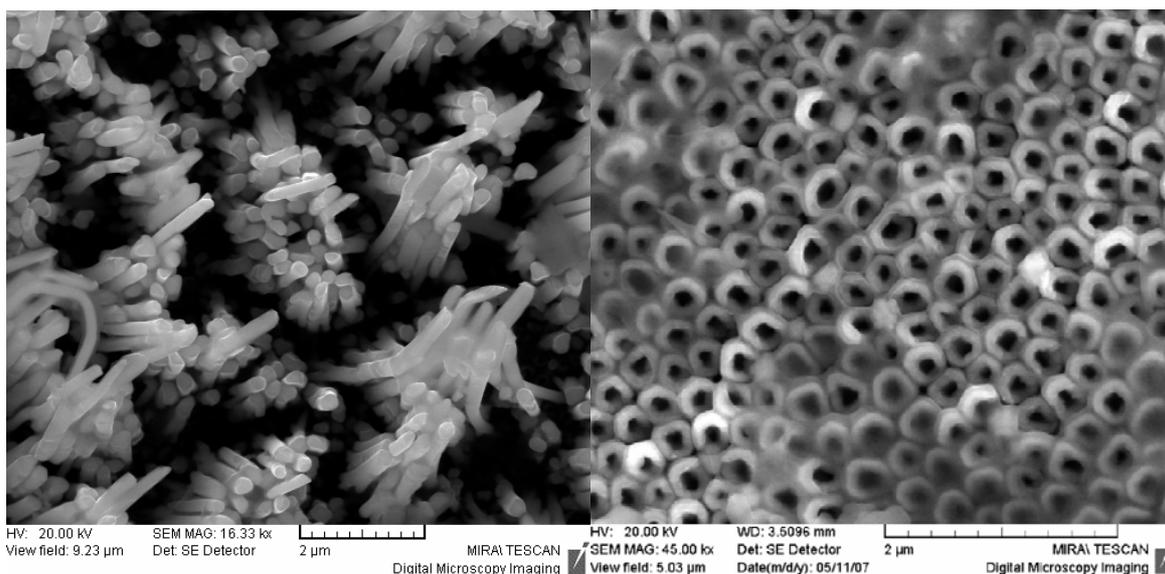
The nanostructures were examined by scanning electron microscopy (SEM). The SEM analyses were provided by **TESCAN s.r.o.**

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References:

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 [2] Stulík K., Amatore Ch., Holub K., Mareček V., Kutner W. *Pure Appl. Chem.*, ©IUPAC., Vol. 72, No. 8., (2000), 1483-1492

Figures:**Fig. 1:** Process of nanostructures creation**Fig.2:** Nanowires**Fig. 3:** Nanotubes