Vertically Aligned Arrays of Metal Nanostructures Fabricated by Direct Galvanostatic Electrodeposition Using Anodic Alumina Templates

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Metal nanostructures (nanowires and nanotubes) are created by electrodeposition of a metal on a conductive substrate which is covered by a nanoporous non-conductive structure. After that, the nanoporous non-conductive structure, which serves as the template, is removed and only the metal nanostructures remain. The whole procedure of nanostructure fabrication is illustrated in Fig. 1.

The nanoporous non-conductive structure is produced by anodization of a thin vapour deposited or sputtered aluminium film. Aluminium (as well as titanium) has a self-assembling ability which occurs during anodization under specific conditions. This ability enables to create the template which contains hexagonally arrayed nanopores. The anodization process can be either one-step or two-step. Two-step anodization, which consists of the first anodization (the first step), subsequent dissolving of the anodized layer, and another anodization (the second step), provides significantly more ordered nanopore array then just one-step anodization [1]. An example of the nanoporous alumina structure is in Fig. 2-a (anodization was carried out in 10% H_2SO_4 and at 24 V. The temperature of the electrolyte did not exceed 10°C).

It is possible to create both nanowires and nanotubes by the template-assisted method. In the case of nanotubes, two techniques for their fabrication exist. A double-templating approach (first reported by Sander et al [2]) consists in creation of nanowires using the Al_2O_3 template, subsequent electrodeposition of another metal and dissolution of the previously created metal nanowires. Therefore, this technique of nanotubes fabrication consists of two electrodeposition processes. The first one leads to creation of a metal template while the second one results in creation of the nanotubes. The other way to create nanotubes using Al_2O_3 template is a single-templating approach (which has been used by our research team). In this case, only one electrodeposition is required. Specific electrodeposition conditions, such as the pH, the concentration, etc., are adjusted in order to create the nanotubes. The nanotubes are probably formed by hydrogen bubbles evolved during electrodeposition. This method is less time-consuming then the double-templating approach because it consists of only one electrodeposition process. An example of nanowires is in Fig. 2-b and nanotubes (created by the single-templating approach) are in Fig. 2-c.

Fabrication of nanostructures can be advantageous in many technological applications, such as cooling systems, optoelectronics, microsensors, etc.

The nanostructures which had been formed by this template-assisted method, as well as the template itself, were examined by scanning electron microscopy (SEM). The SEM analyses were provided by **TESCAN s.r.o.**

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References:

[1] Yakovleva N. M., Yakovlev A. N., Chupakhina E. A. *Inorganic Materials*, Vol. 34, No.7, (1998), 711-713.

[2] Sander M. S., Gao H. *J. Am. Chem. Soc.,* Vol. 127, No. 35., (2005), 12158-12159

Figures:

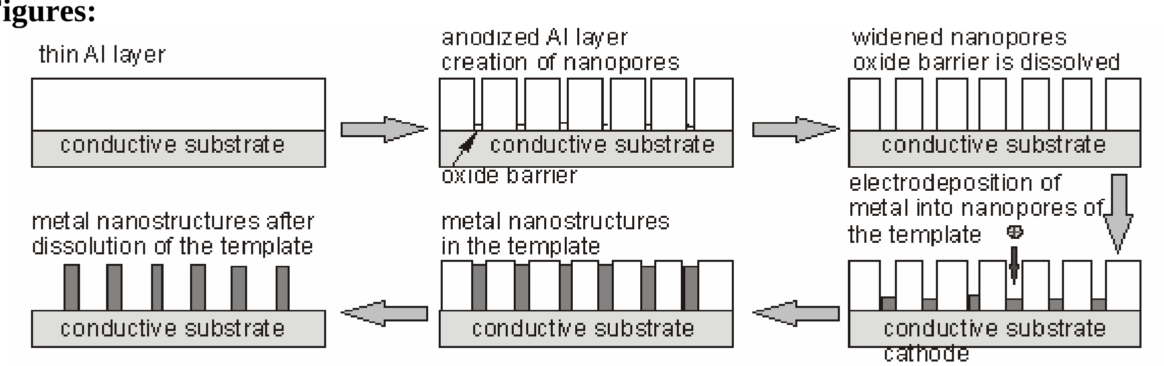

Fig. 1: Template-assisted electrodeposition method

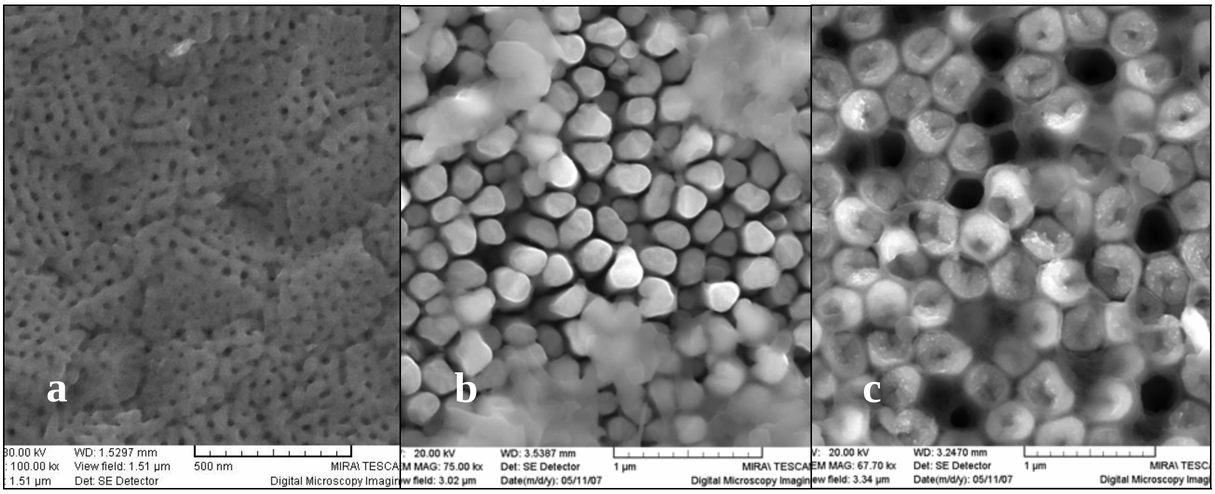

Fig. 2: Nanostructures
a) *nanoporous alumina template* b) *nanowires* c) *nanotubes*