Formation of self-assembled metal/silicon nanocomposites

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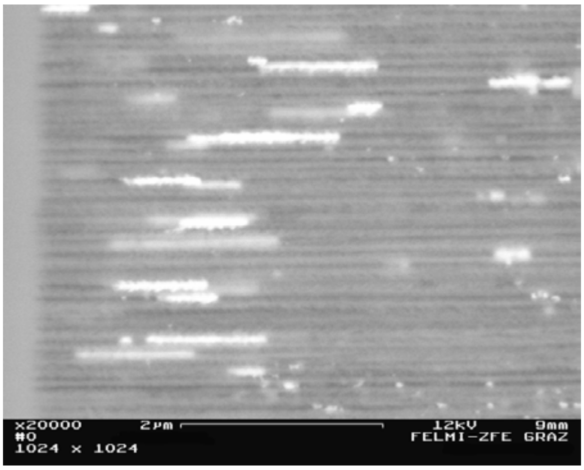
The fabrication of nanoscopic silicon based membranes has been carried out by using a non-expensive electrochemical preparation technique. For these purposes an n^+-silicon wafer is anodized to create oriented pores with typical diameters around 50 nm. The length of the channels is up to 50 µm which yields to an aspect ratio of 1000. Pores with diameters in the micrometer range exhibit quite smooth pore walls [1] but get rougher and more dendritic with the reduction of the diameter. The generated mesopores offer a dendritic growth but the length of the side-pores could be sufficiently suppressed to obtain clearly separated channels with even a quite regular self-assembled pore-arrangement. The pores of such templates are filled with a metal, especially a ferromagnetic one to obtain an array of nanostructures. Metal-deposition within such high aspect ratio pores down to the pore-tips is a great challenge [2] but succeeded. The metal-loading consists of precipitated particles of different shapes from spheres to elongated particles up to wires. The extension of the deposited wires reaches a few micrometers (aspect ratio 100). This achieved nanocomposite can be varied in two ways. On the one hand by the modification of the nano-architecture of the silicon template, on the other hand by altering the metal deposition process. The porous silicon membrane can be modified within a certain regime in pore-diameter, pore-length as well as interpore-spacing which can be influenced by the current density and the electrolyte concentration, respectively. The spatial distribution of the deposited metal can be influenced by varying the applied current and the frequency of the current pulses. The nanoparticles can either be distributed over the whole template or accumulated in the lower third part of the porous layer or occur mainly in the surface region. Also the preferential shape (spheres, ellipsoids, wires) of the metallic nanostructures can be regulated. Furthermore a metal-layer covering the surface can be realized by longer pulse durations. A calamity of managing the structure of the described system is that some of the influencing parameters are not completely independent from each other. Characterization of the template as well as of the deposited metal-particles is performed by scanning electron microscopy (SEM), especially in recording the back scattered electrons and EDX-mapping respectively to get element sensitive information. The introduced silicon based nanocomposite offers the opportunity to change between different nano-architectures by accurate adjustment of the electrochemical fabrication parameters and promises applicability for magneto-optical, magnetic and spintronic devices suitable for silicon based technology.

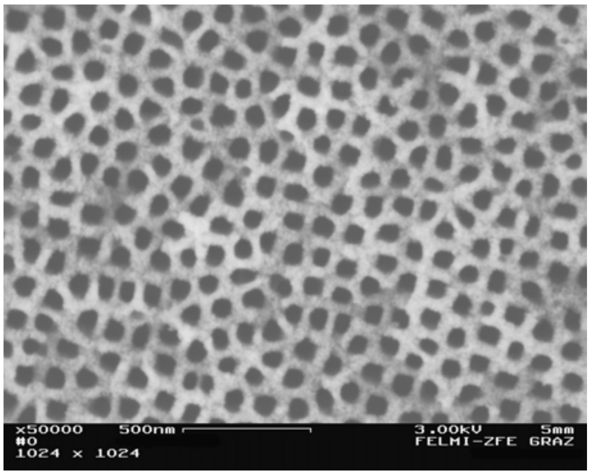
References:

[1] V. Lehmann, U. Grüning, Thin Solid Films, **297** (1997) 13.
[2] C. Fang, E. Foca, S. Xu, J. Carstensen, H. Föll, J. Electrochem. Soc. **154** (2007) D45

Figures:



a)



b)

a) Ni-wires (length 2 µm, diameter 50 nm) precipitated within the channels of a silicon matrix.
b) Scanning electron micrograph showing the top-view of the sample.