CENTRE OF NANOTECHNOLOGIES FROM IMT-BUCHAREST

MATNANTECH (New Materials, Micro and Nanotechnologies) - is a Romanian programme in the National Plan for Research, Development and Innovation (PNCDI), launched in June 2001. See our MNB, vol.2 / no.2-3 for details.

NANOMATERIAL CHARACTERIZATION/INVESTIGATION BY LOW-FREQUENCY NOISE MEASUREMENTS

MATNANTECH Project no. 27 (2001-2004)

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Noise measurements were done in the ohmic region of the I-V characteristics of platinum nanoparticle films (Fig. 1) deposited on SiO_2/Si substrates by laser ablation. 1/f-like noise was found in all samples, with the frequency exponent varying between 0.7 and 1.4. Fig. 2 shows that the relative noise intensity (S_V/V^2, V-voltage) depends on the film conductance/coverage. Apparently, for smaller conductance /coverage, the general tendency for the noise intensity is to decrease with the sample conductance. After a minimum (sample NN9), the noise intensity not only "recovers" but also experiences a slight increase for higher conductance. One supposes that the very unusual increase of the 1/f noise intensity with the sample conductance is brought about by nanoparticles interacting with/(sinking into) the substrate. The role of the substrate came to the fore by X-ray diffraction analysis. Figure 3 shows comparatively the X-ray diffractograms of the samples NN14 and NN15. For the sample NN14, both platinum lines, at (111) and (200), are located above two very broad peaks which correspond to a platinum amorphous phase. The deposited material on NN15 sample is almost entirely amorphous. Superposed on this large "amorphous" peak are some peaks which are associated with a crystalline state of Pt_3Si. A weak and very extended peak is also observed at about 21.11O in NN14. It can be assigned to an amorphous state of Pt_3Si. These results strongly support the hypothesis that deposited material interacts with the substrate. Tunneling between metal (nano)islands which are partially embedded into the SiO_2 matrix can be the source of the excess 1/f noise observed but the presence of $PtSi_3$, if any, could also favor the manifestation of some other conduction pathways.

In conclusion, SiO_2 substrate induces 1/f noise in platinum nanoparticle films. Our results could be of some relevance for highly functionalized applications of nanoparticles (e.g.: island 1/f noise in single electron transistor) or even for "classical" application of nanoparticles (e.g.: clarifying the fundamental role of the SiO_2 substrate in the catalytic processes).

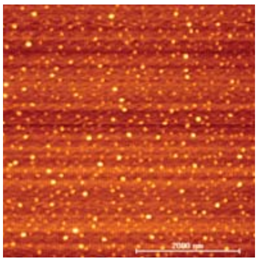

Fig. 1 AFM image of the laser ablation grown platinum nanoparticles on SiO_2/Si substrate

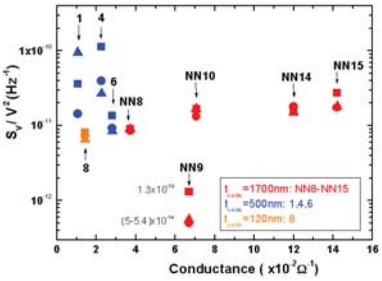

Fig. 2 - Dependence of S_V/V^2, at f=10Hz, on film conductance. For each sample, the triangle, square and dot represent the noise data for three different currents.

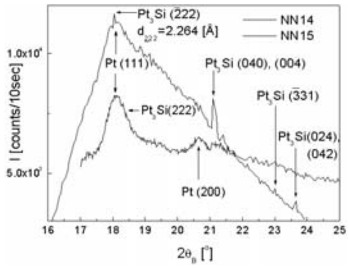

Fig.3 - X-ray diffractograms of the samples NN14 and NN15.

POROUS SILICON MATRIX FOR APPLICATIONS IN BIOLOGY

MATNANTECH Project no. 69 (2001-2004)

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1. RESEARCH OBJECTIVES

- study of cell culture growth on the surface of the microporous silicon. Bulk crystalline silicon is rendered porous by partial electrochemical dissolution in hydrofluoric acid based solutions; depending upon the etching conditions, porous silicon has a very complex, anisotropic nanocrystalline architecture of high surface area;
- technologies for porous silicon surface modification in order to ensure its biocompatibility;
- realisation of a porous silicon matrix as a test-support for cell growth.

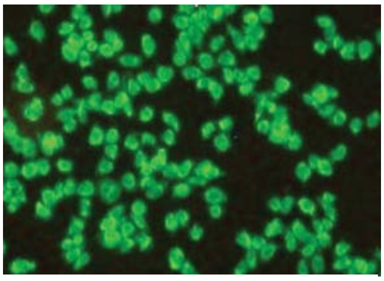

Fig.1. CHO cells grown on PS substrate modified by a thin carbon layer deposition

3. RESULTS

On different porous silicon (PS) layers with 35-50% porosity some treatments for the surface modification/stabilisation were realised: thermal treatment in dry O_2, at 300°C, and 800°C; 0.5nm deposited carbon monolayer; 30-40nm deposited carbon layers; hexametildisilazane treatment; 50nm a-SiC deposited by hexametildisilane. The PS as-prepared surface is hydrophobic and these treatments lead to a hidrophilic surface, necessary for the living cells growth.

On these structures, three cellular lines:cancerous, mamallian and mouse ovarian (CHO) cells were grown (Fig. 1 and Fig.2). The development of tissue engineering is directly related to changes in materials technology.

We intend to realize a matrix of nanostructured silicon as support for bone repair, by additional layers deposited on porous silicon, as hydroxiappatite.

Silicon nanostructures, by appropriate control of pore size, and porosity, and by modification of their surface lead to biospecific cell adhesion.

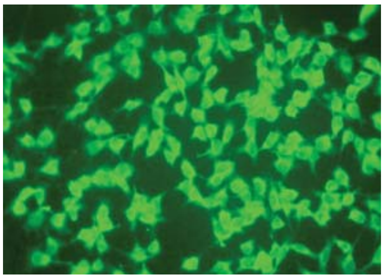

Fig. 2. CHO cells grown on PS substrate subjected to a thermal treated in N_2.

BIOCHIPS FOR DETECTING ELECTROCHEMICAL ACTIVITY

MATNANTECH Project no.79 (2001-2002)

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PROJECT TARGET: the design and the fabrication of a new system based on micro and nanoelectrode arrays for the biological material characterization by electrochemical measurements.

RESEARCH OBJECTIVES

» study of the electron transfer from biological material to the electrode arrays;
» design, fabrication and characterisation of the silicon micro, nano - electrodes arrays chips and their biomedical applications;
» development of an analysis system.

The main advantages of micro and nanoelectrodes for biochemical sensor development can be briefly stated as follows: the small electrode size requires a small sample volume; a significative enhancement of the measured current density due to the greater number of electrodes on the chip, all of them connected at the same potential; the quick response allows monitoring of the low-frequency fluctuation of signals and rapid recording of steady-state polarization curves.

RESULTS: different types of nano- (Fig. 1), micro- (Fig. 2) and macroelectrode arrays (Fig. 3) were realized using standard processes from silicon device technology.

Another application of the integrated pyramidal electrode chips with silicon dioxide and gold on silicon surface is the possibility to use them in electrochemical or conduction measurement of living cell cultures.

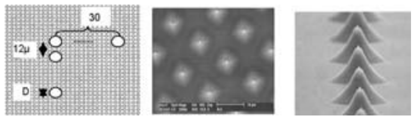

Fig. 1. Nanoelectrode arrays

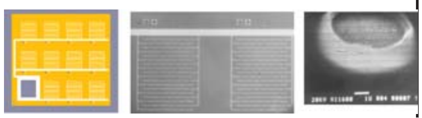

Fig. 2. Microelectrode arrays

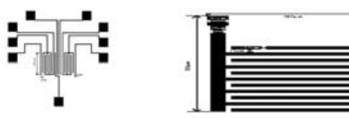

Fig. 3.Interdigital macroelectrode arrays