Fabrication by Dip-Pen Nanolithography of Polypyrrole Nanowires for DNA biosensors

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Conducting polymers constitute an attractive alternative to metals and semiconductors as sensing elements in biosensor devices. They are low cost, easy processing materials at the micro and the nanoscale with controllable mechanical and electrical properties and, particularly important in the biomedical field, they show high biocompatibility[1].
We propose the fabrication of conducting polymer nanowires, by the method of Dip-pen nanolithography, for the selective recognition of single-base mismatches through electrical measurements. This would be used further on in DNA sensor by depositing the polypyrrole nanowires between two metal contacts previously deposited on top of a silicon oxide substrate. To address these challenges, Dip-pen[2] and nanoimprint and focused ion beam (FIB) lithographies, combined to electrochemical deposition,[3] will be used as main processing techniques. Once these challenges are met; a large reduction of the sequencing cost of the DNA can be achieved by using Conducting Polymer Nanowires as DNA sensors.
Dip-pen nanolithography is a technique developed in 1999 by C. Mirkin et al. [4] where the ink is deposited onto a surface via cantilever. The use of the so called inkwells (microfluidic chips) enables the deposition of bio-molecules which are in a buffered solution. The cantilever is introduced in the wells, retracted abruptly and left drying to bring it into contact with the surface and write the nanosize pattern.
Dip-pen experiments have been performed with a NSCRIPTOR system from Nanoink (Skokie, USA) at room temperature (20°C ±1ºC) and humidity ranging from 30% to 45% on silicon oxide. An image of the written nanowires at 21^0C and 41% of humidity is shown in figure 1, done after writing with the same tip and Dip-pen equipment, just by changing the scan velocity. Higher humidity increases the nanowire dimensions, so it should be a parameter optimized when critical size tolerances are needed.
Another parameter influencing the nanowire dimensions is the deposition speed, which should be highly controllable with the technical set-up. Studies of the nanowire dimensions as a function of the deposition speed were performed in order to determine the optimum conditions and control the process of deposition. The figures 2 and 3 show the decay tendency of the size while increasing the speed, at 21^0C and humidity within 32% and 34%. Similar results were obtained for different environment conditions.
In summary, we showed that it was possible to obtain nanowires with tailored dimensions (height and diameter) by controlling environmental conditions (temperature and humidity), and that we could deposit our structures in a certain location between electrodes for further processes.

References:

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[2] Tang Q, et.al. Sensor Actuat B-Chem 2008; 13: 379.
[3] Yun M, et. al. Nanosensing: Materials and Devices. 2004; 5593: 200
[4] C. Mirkin, et. al. Science. 1999; 283, 661

Figures:

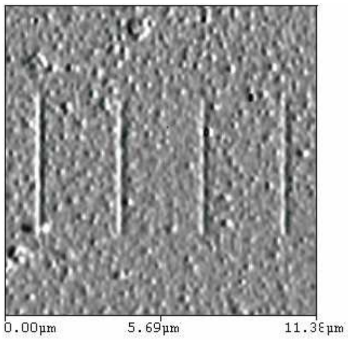

Fig.1.- LFM image in contact mode of Nanowires at different writing speeds.

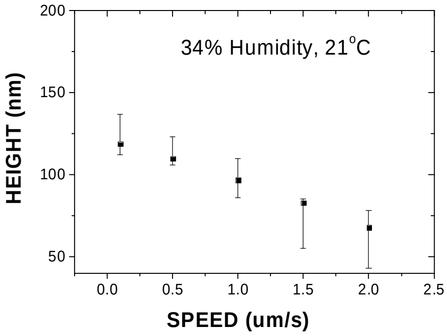

Fig.2.- Decrease in height with higher speed.

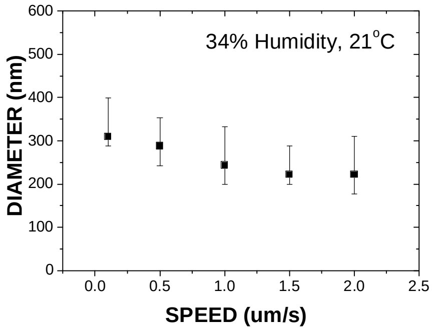

Fig.3.- Decrease in diameter of the Nanowire with increasing velocity.