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

T. Galán[1, 3], S. Oberhansl[1,2], E. Martínez[1, 2], J. Samitier[1, 2, 3].
[1]Nanobioengineering group, Institute for Bioengineering of Catalonia (IBEC), Josep Samitier 1-5, 08028, Barcelona, Spain.
[2]Networking Research Center on Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Barcelona, Spain.
[3]Department of Electronics, University of Barcelona, c/ Martí i Franquès 1, 08028 Barcelona, Spain.
tgalan@ibec.pcb.ub.es

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 show high biocompatibility, a particularly important requirement for biomedical applications [1].
We propose the fabrication of conducting polypyrrole polymer nanowires, by the Dip-pen nanolithography method. This nanomaterial, would be used further on in the construction of a DNA sensor by depositing the polypyrrole nanowires between two metal contacts previously fabricated on top of a silicon oxide substrate. To address these challenges, Dip-pen[2] deposition combined with standard optical lithography will be used as main processing techniques.
Dip-pen nanolithography is a technique developed in 1999 by C. Mirkin et al. [3] 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 for the writing of the nanosize pattern (Fig.1).
Dip-pen experiments have been performed with a NSCRIPTOR system from Nanoink (Skokie, USA) at Room Temperature (20°C ±1ºC) and relative humidity ranging from 30% to 40% on silicon oxide. An image of the written nanowires at 0,1, 0,5, 1,0 and 1,5 μm/s writing speeds, at 21ºC and 40% of humidity is shown in Figure 2. The LFM (Lateral Friction Mode) has been obtained with the same tip and equipment used for writing. Several parameters influence the nanowire dimensions [4,5], as the writing speed, the temperature and humidity, being these two last ones controlled by an environmental chamber (EChamber, Nanoink). Studies of the nanowire dimensions as a function of the writing speed and humidity at constant temperature were performed in order to determine the optimum deposition conditions. Figure 3 evidences the decay tendency of the size while increasing the speed, at Room Temperature and several humidities within the range of our study. Higher humidity increases the nanowire dimensions, so it should be also a parameter optimized when critical size tolerances are needed. Additionally, nanowire deposition between prepatterned metallic contacts have been achieved as seen in figure 4 by an AFM image showing a nanostructure located in a specific area.
Finally, we showed that it was possible to obtain polypyrrole nanowires with tailored dimensions (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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[3] C. Mirkin, et. al. Science, **283** (1999) 661
[4] J. Lim, A Mirkin. Adv. Mater. **14**(2002) 20
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Figures:

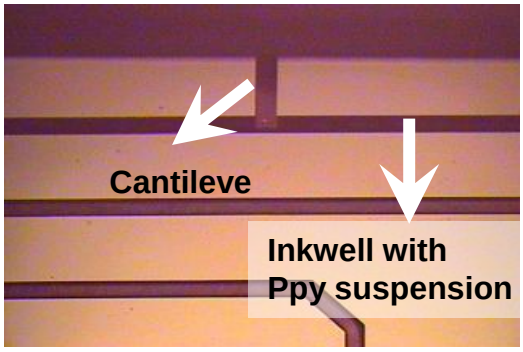

Fig.1- Process of loading the ink on the tip, by the help of the Inkwells

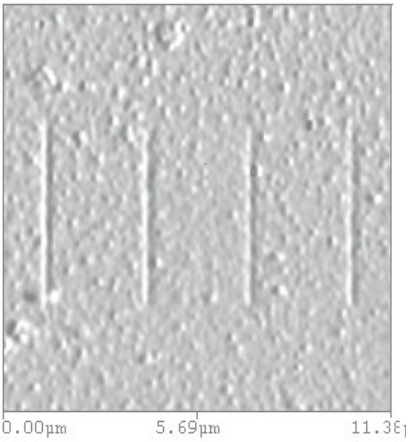

Fig.2- LFM image in contact mode of Nanowires at different writing speeds.

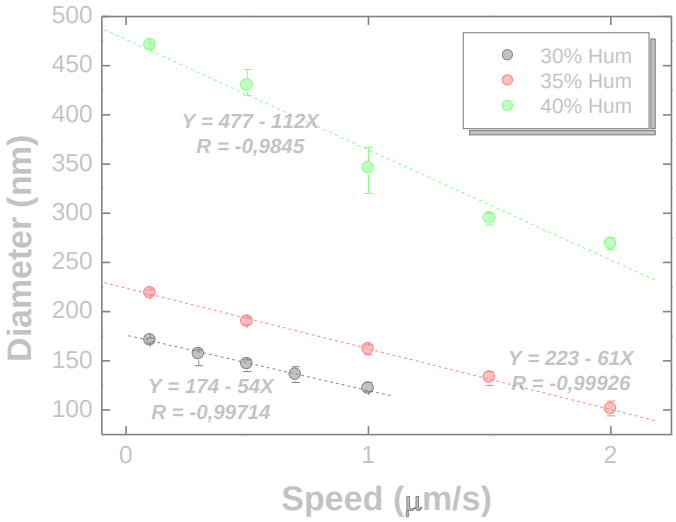

Fig.3- Dependence of the Nw diameter with the writing velocity, for different humidity values. Dashed lines correspond to the linear fits.

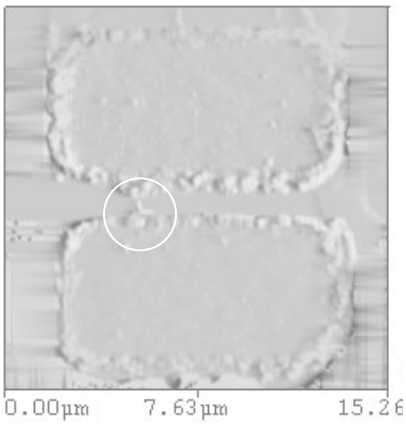

Fig.4- Topography AFM image of a Nanowire written in a gap between metallic contacts