Electronic detection of DNA hybridization

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The integration of biomaterials with carbon nanotubes, CNTs, has promoted an interdisciplinary field of CNT- based nanoelectronics and nanobiotechnology. The quick detection of anomalous genes responsible for a congenital disease is highly desired and the reading of the human genome has opened the possibility of early detection and diagnoses of congenital/terminal diseases. Electrical biosensors that use immobilized nucleic acids are especially promising in biosensing applications because of their potential for miniaturization and automation as well as their more simple instrumentation for on-site and point of care applications.

Here we present the label free detection of single strand DNA using a large array of CNTFET. The paper presents a methodology for avoiding no specific DNA adsorption on CNTs providing at the same time a stable binding for DNA

The DNA was covalently bonded to a polymer; poly(methylmethacrylate$_{0.8}$-co-polyetyleneglycolmethylmethacrylate$_{0.1}$-cosuccinimidyl methaccrylate) that was anchored no covalently to the CNT. Using this approach and the statistically treatment of the electrical characterization data of a large array of devices, the DNA hybridization has been unequivocally detected. The changes of the electrical CNTFET characteristics upon interaction with several chemicals used for binding the DNA and upon DNA hybridization are reported.

In Figure 1, a AFM image of a SWNT joining the source and drain electrodes are shown. A schematic diagram of the reactions of the succinimidyl groups of the polymer with the amine groups of a single strand aminated DNA are presented in Figure 2. After bonding the DNA the remaining succunimidyl groups were blocked with ethanol amine before DNA hybridization.

In Figure 3 it can be seen the I/V plots corresponding to the electrical characterization before and after each of the steps. The DNA hybridization produces a shift of the I/V plot towards negative voltages and a decrease of the current for the p-type conductance what allows its electronic detection. Upon hybridization, the negatively charged backbone of target DNA is added to that of previously stacked probe. When ss DNA hybridizes with complementary DNA, three hydrogen bonding is generated for the pairing guanine-cytosine and two bonding for adenine-thymine pair. The consumption of electrons in hydrogen bonding results in smaller amount of electron transfer towards the CNT channel. This findings regarding the decrease of the source-drain current and shifts of the Vth to the negative values, Figure 4, are in agreement with the data reported by Star (1) working with CNTFET made with CNT networks.

References:

[1] 7.- Star A. et al. Proc. Natl. Acad. Sci. USA (2006) 103, 4, 921-926 (2006)

Figures:

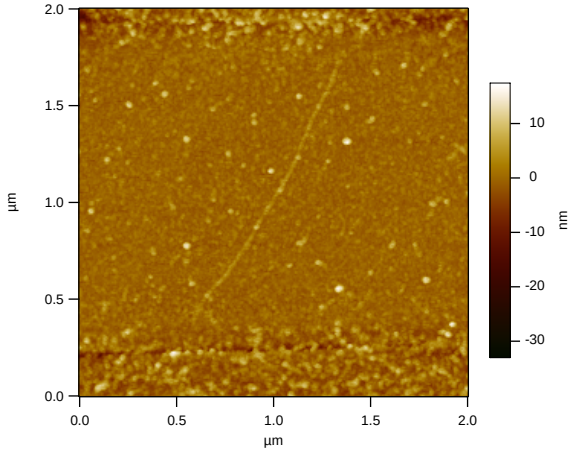

Figure 1.- AFM images of a SWNT bonding drain and source electrodes

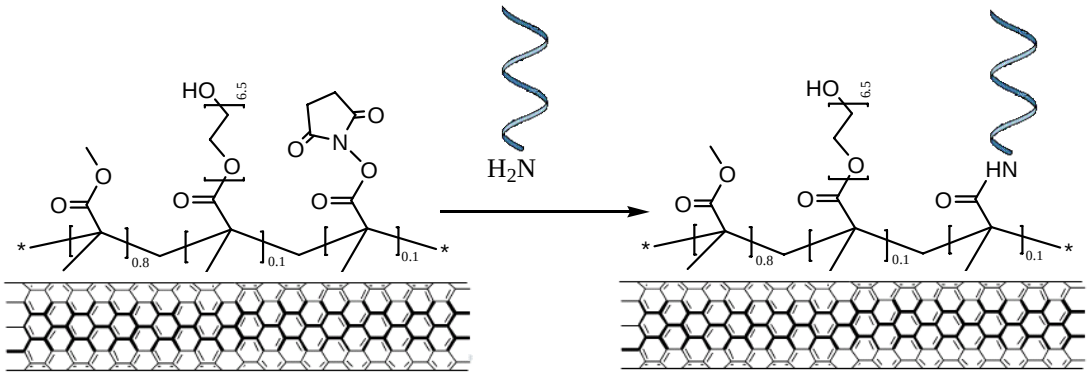

Figure 2.- Schematic diagram of the covalent functionalization of ss DNA-NH2 with the polymer bonded no-covalently with the SWNT

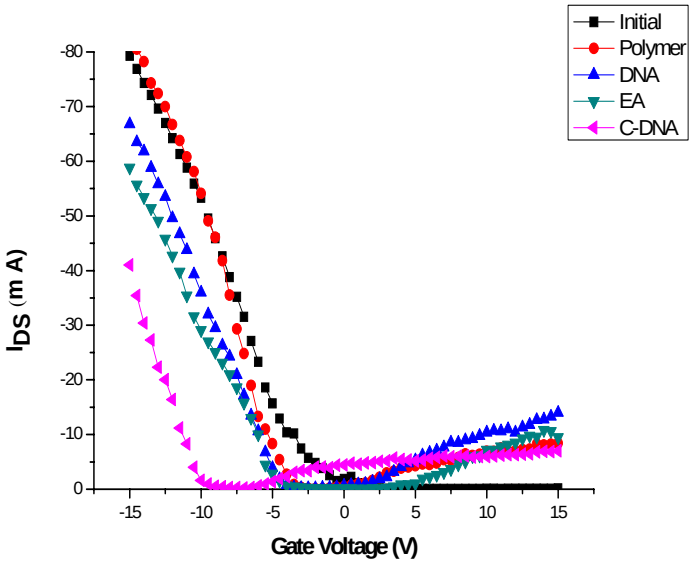

Figure 3.- Source-Drain I/V plots evolution after depositing the chemicals and biomolecules.

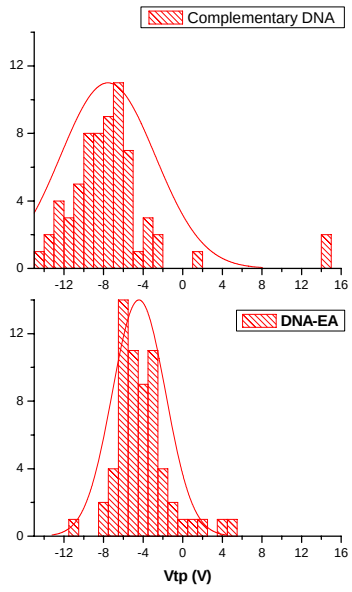

Figure 4.- Histograms showing the changes in the Vtp of the devices upon DNA hybridization.