BIOSENSING WITH GRAPHENE FIELD-EFFECT TRANSISTORS

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Graphene, a recently isolated bidimentional material, has attracted a lot of attention in biosensing due to its high sensitivity, chemical stability and biocompatibility. It has quickly seen applications as electrochemical sensor, and has more recently been applied to biosensing in the form of electrolyte-gated field effect transistors, where its high carrier mobility provides superior sensing capabilities. In a EGFET, the biomolecules in the vicinity of graphene apply an electrostatic field which is detected electrically. In order to provide specificity to particular biomarkers, a bio-functionalization procedure has been developed which can be applied to the detection of proteins and DNA strand, by immobilizing a probe, either the specific antibody or the complementary DNA sequence. The biorecognition of the probe and the target brings the charge of the target in the vicinity of graphene, which induces a local electrostatic gating of graphene. The resulting device signal is as a shift in the transfer curve of the EGFETs.

In this work, we used standard clean room technology to fabricate the EGFETs at the wafer scale[1]. The functionalization procedure is based on the use of a pyrene derivative (PBSE) which attaches to graphene by π-π interaction, and holds at its other end an ester group available for a reaction with an amine from a probe. The sensor was characterized for detection of both proteins and DNA strands. The proteic biomarker MMP-9, related with the hemorrhagic transformation of ischemic stroke, was detected by the immobilization of specific antibody, with a limit of detection of 0.01 ng/mL (0.1 pM) and linear range up to 10 ng/L. The characterization as DNA sensor was performed using a 25 nucleotide strand specific to a grape variety used in Port wine. The sensor showed a linear range between 1 aM and 100 fM with a selectivity for single nucleotide polymorphism (SNP) of 10 aM. The curves for the DNA sensor were normalized by the surface density ρ of the probe DNA. This density was obtained by measuring the shift in the transfer curve before and after immobilization, and using an electrostatic model to connect the shift to the electric field resulting of a uniform distribution of charges at a known distance of graphene:

$$\rho = \frac{2\varepsilon_0 \varepsilon_r \Delta V_0}{m e d_D}$$

where ε_r and ε_0 are the dielectric permittivities of water, d_D is the Debye length, ΔV_0 is shift of the transfer curves, m is the number of charges in the biomolecule (assuming each nucleotide brings one electric charge) and e is the elementary charge.

The low limit of detection of these sensors show their relevance for health and food industries.

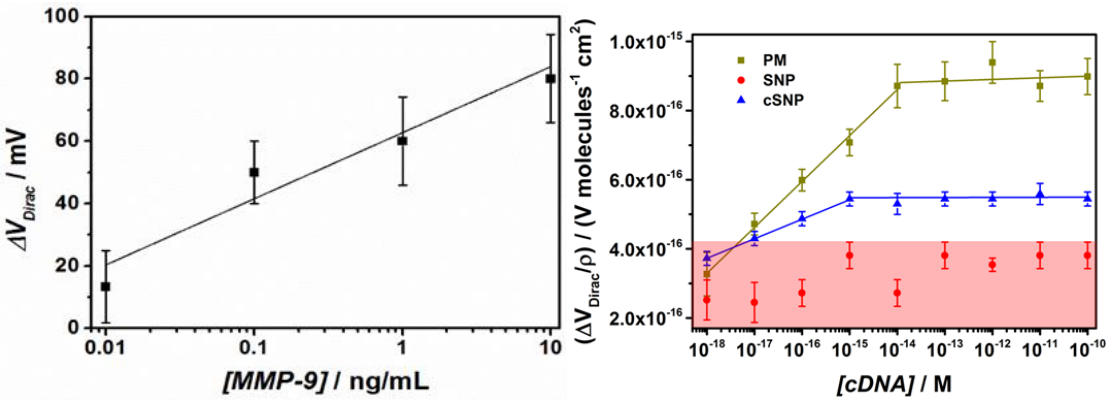

Figure 1: Calibration curves for A) an immuno-FET and, B) a DNA-FET. The curves are obtained by the average of five independent sensors, in order to obtain the error bars.

REFERENCES:

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