aM Label-free detection of DNA hybridization with electrolyte-gated graphene field-effect transistors

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In recent years biosensing systems became ubiquitous in the medical and biomedical fields, spanning a large range of applications, from prognosis and/or diagnosis of diseases, to personalized medicine. DNA detection can provide crucial information in more than one field, including research on molecular biology, genetic disease diagnosis, biological informatics, forensics and environmental monitoring, to mention just a few. Hence the relevance of the field, which has not stopped to grow since the elucidation of the genetic code for protein synthesis.

Graphene was the first 2D material to be studied in detail. It has exceptional properties, including high 2D electrical conductivity, large surface area, high chemical stability and low cost. The fact that it provides an exposed, natural 2D surface populated with high-mobility electrons or holes, depending on the gating potential applied to the surface, allows for the design of novel types of chemical sensors based on a field-effect transistor (FET) architecture. However, graphene high sensitivity and chemical stability comes at the cost of a poor analyte selectivity. Therefore, biorecognition with graphene requires surface functionalization.

Here we develop a FET based on a single graphene layer for label-free detection of target DNA hybridization with probe DNA. The probe immobilization is achieved with the help of a pyrene linker, attached to the graphene surface via π-π interaction. The FET is designed with an in-plane receded gate, with source and drain contacts, prepared to support a liquid-gate dielectric (~10 µL electrolyte droplet) that closes the high-impedance gate-source circuit. Transducing is based on local gating whenever a biorecognition event, i.e. DNA hybridization, takes place at the transistor channel surface. By consecutive monitoring of the FET transfer curve, the Dirac point movement is tracked, showing a shift towards more positive potentials with increasing target DNA concentrations until it reaches a plateau at 100 fM. Detection down to aM levels, while keeping sensitivity to single nucleotide polymorphism, is achieved. The detection of aM levels of DNA hybridization using a FET is a 3 order of magnitude improvement on previous detection levels [1] and is among the best from all detection strategies [2].

References

[1]C. Zheng, L. Huang, H. Zhang, Z. Sun, Z. Zhang and G.-J.Zhang, *ACS Appl. Mater Interfaces*, 7 (**2015**), , 16953-16959

[2] W. Ma, H. Kuang, L. Xu, L. Ding, C. Xu, L. Wang and N. A. Kotov, *Nature Comm.*, 4(**2013**) Article number: 2689

Figures

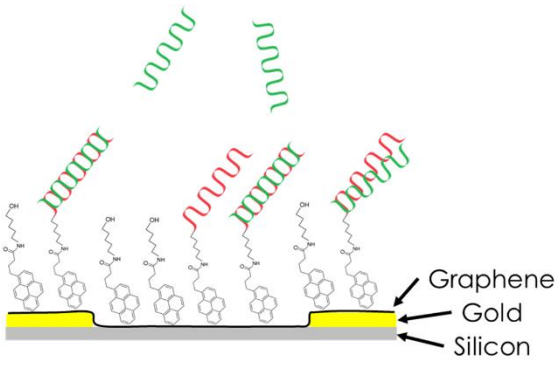

Figure 1: Schematic representation of the EGFET for DNA hybridization detection.