Biosensing with Graphene Devices

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Graphene, a two-dimensional sheet of carbon atoms arranged in a honeycomb lattice, is an emerging material for biosensing applications [1]. Its unique electronic properties, high chemical and mechanical stability, and cyto- and biocompatibility make it especially suited for multimodal biosensing. In particular, graphene field-effect transistors (GFETs) can be set to sense ionic currents and functionalized with biorecognition elements. Our group has extended experience fabricating and testing graphene sensors for DNA and protein detection in optimized buffers and body fluids such as blood and saliva using synthetic or extracted DNA from biological samples [2,3]. We present microelectronics label-free biosensing platforms based on liquid-gate graphene field-effect transistors for DNA hybridization detection with SNP sensitivity and antigen-antibody assays with a tunable dynamic range. The systems are operated by delivering microdroplets (~10 uL) of analyte directly onto the graphene transistor channels followed by data acquisition or by inserting the chip into a microfluidic chamber connected to a syringe pump and a multiposition valve for automated measurements. The flow system reduces in 50% signal drifts observed when using droplets. Projects based on the GFET platform with different layouts for simultaneous neurotransmitters and electrical events detection in the brain, multiplex malaria diagnostic detection of several Plasmodium species, wine authenticity control based on DNA SNP analysis, and extracellular matrix biomarkers relevant for ischemic stroke therapy are ongoing. You can learn in detail about some of these in this conference, reported by team members. In another approach, we use the z^{-4} nanoscale distance-dependence of the fluorescence lifetime for fluorophores located in the vicinity of graphene to track the hybridization of fluorescently labeled DNA beacons attached to graphene with complementary (target) DNA added in solution. In this way, we can monitor the vertical displacement of the label during DNA-beacon hybridization with an axial resolution reaching down to 1 nm [4].

REFERENCES

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[3] Campos R *et al*., ACS Sensors, 4 (2019) 286.
[4] Adão RM *et al.*, 2D Materials, 6 (2019) 045056.

FIGURES

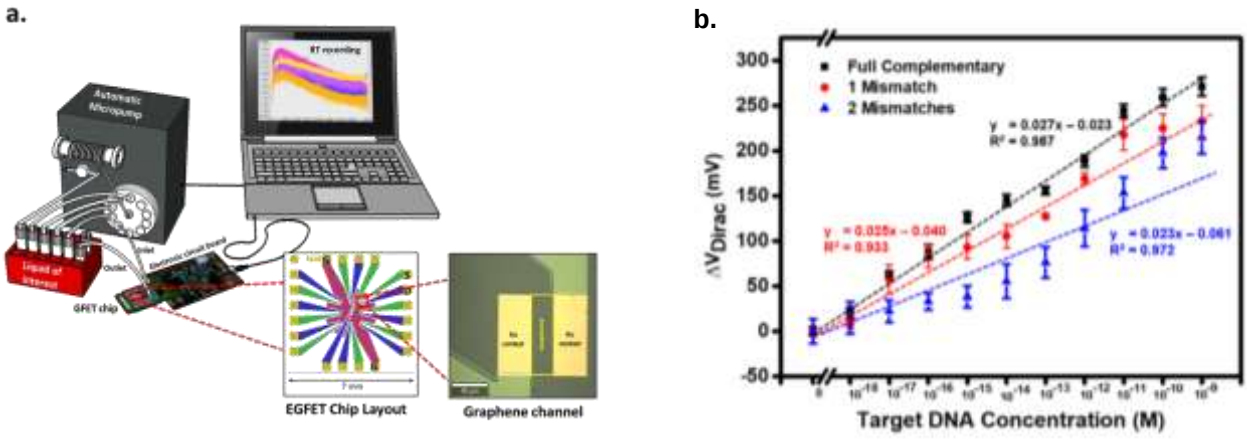

Figure 1: Set up for benchtop GFET biosensor operation coupling to a microfluidic system. b) DNA hybridization calibration plots, showing SNP sensitivity.