Graphene Liquid-Gate Transistors Functionalized for DNA Detection

Telma Domingues [1,2]
J. Rafaela Guerreiro[1], A. Ipatov[1], M. Prado[1,2], D. Y. Petrovykh[1], J. Borme[1], Pedro Alpuim[1,2]

[1] *INL-International Iberian Nanotechnology Laboratory, 4715-330, Braga, Portugal*
[2] *CFUM-Center of Physics of the University of Minho, 4710-057, Braga, Portugal*

pedro.alpuim.us@inl.int

Miniaturized DNA analytical devices are essential tools for the successful development of Point-of-care testing, contribute to the development of so-called "intelligent factories" (Industry 4.0), and automated environmental monitoring, due to their possibility of integration, automation, and connectivity between analytical devices. We propose the development of a miniaturized DNA sensing device comprising 3 modules: DNA extraction and purification, the isothermal DNA amplification, and the detection, which, in our case, is based on liquid-gate graphene field-effect transistors (GFETs). Sensor readout consists of a home-made electronic platform, with the size of a credit card, to ensure portability (Fig. 1E). Here, we report on the detection module: the GFET sensor chip and a PDMS flow cell, fitting the sensor layout, are assembled and then inserted in the portable platform (Fig. 1C,D). This system, connected to a syringe pump and a multiposition valve, allows for automation, improving the precision over manually operated ones [1]. The flow system allowed to reduce in 50% the signal drifts observed in bare graphene transistors. For the detection of DNA, the graphene transistor channel is functionalized with a probe (30 nucleotides, complementary to the DNA target). Graphene functionalized with a linker through π-π stacking was used to covalently attach the amine modified DNA target by amine coupling. Different linkers (PBSE, FSC and AO succinimidyl ester) in distinct solvents (ethanol, DMSO, and DMF) were tested for surface coverage by QCM (Quartz-Crystal Microbalance). The highest DNA surface coverage (1.0 x10^{13} molecules/cm^2) was obtained using PBSE in DMF. The surface density of probes was also calculated by XPS showing agreement with QCM results and with previous work [2]. To block unreacted ester groups of PBSE, ethanolamine is added before introducing the solutions containing the target molecules. Each modification step was monitored by measuring 10 transfer curves and, from the last 3 curves, computing the average of the gate voltage values at which maximal channel resistance is observed (V_{Dirac}). The observed shifts in V_{Dirac} are consistent with a mechanism of local gating of graphene by charged molecules [3].

References

[1] Xu-Wei, C.; Ming-Li, C.; at al. Trends in Analytical Chem., 9 (2008) 762-770
[2] Gong, P.; Chi-Ying Lee; et al., Anal. Chem., 78 (2006) 3326-3334
[3] Campos, R.; Borme, J.; et al. ACS Sensors, 2 (2019) 286–293

Figures

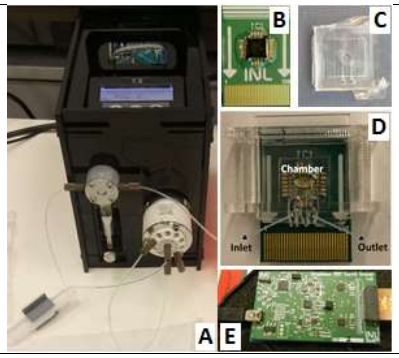

Figure 1: Detection module, **A)** Flow injection system; **B)** multi GFET chip; **C)** PDMS chamber; **D)** PDMS/GFET chip; **E)** platform readout.

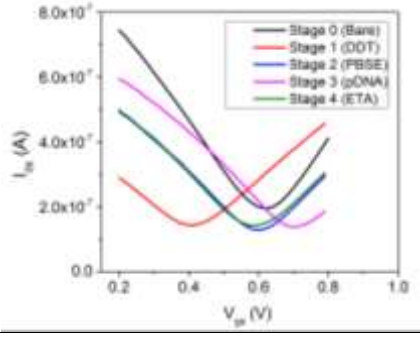

Figure 2: Transfer curves after each stage of the GFET channel functionalization.