Lab-on-a-chip DNA sensor based on graphene electrolyte-gated field-effect transistors

J. Borme[1]
R. Campos[1], J. Rafaela Guerreiro[1], P.D. Cabral[1], C. Abreu[1,3], M. Martins[1], P. Alpuim[1,2]

[1]*INL - International Iberian Nanotechnology Laboratory, Braga, Portugal*
[2]*Center of Physics, University of Minho, Braga, Portugal*
[3]*Medical School, Swansea University, Swansea, UK*

jerome.borme@inl.int

Lab-on-a-chip (LoC) for the detection of complex diseases are growing in importance and normally require the detection of multiple targets in an autonomous and portable fashion. Taking advantage of graphene low-dimensionality, high carrier mobility and chemical stability, we developed a monoplex assay based on DNA label-free sensors, made of graphene electrolyte-gated field-effect transistors (FETs) in a relatively simple design, with high sensitivity and transducing capability. Graphene geno-FETs with a receded, integrated gate architecture [1], are fabricated at the 200 mm wafer scale, for detection of synthetic DNA sequences. The graphene FETs were manufactured by patterning gold contacts on an oxidized silicon substrate [2], passivating the current lines and transferring CVD-grown graphene. To ease practical experiments, we developed a reading platform, composed of a disposable graphene FET chip, optionally wire-bonded to an inexpensive chip carrier, and a credit card format electronic control board including: a 16 bit digital-to-analogue signal generator, generating the gate voltage sweep, a current source component, a 16 bit analogue-to-digital converter, and a CMOS matrix switch array to address up to 24 contacts, used to address a common gate, a common source, and up to 22 individual sensor drains. The board is controlled by a 32 bit microcontroller and communicates with a host computer by a USB, which also powers the board. A laptop computer, with a custom software, is used to control the experiment.
The LoC measures transfer curves of the transistors as a function of time and tracks the gate voltage corresponding to the maximum channel resistance. This voltage is, in turn, dependent on the modulation of the electric double layer that forms at the interface between graphene and the droplet containing the target DNA, whenever hybridization between probe and target DNA occurs. The graphene device is able to detect the target DNA in concentrations down to 10 aM, in a range up to 10 fM.

References

[1] N C S Vieira *et al.*, J. Phys.: Condens. Matter 28 (2016) 085302.
[2] R. Campos *et al.*, Microelectronic Engineering, 189 (2018) 85-90.

Figures

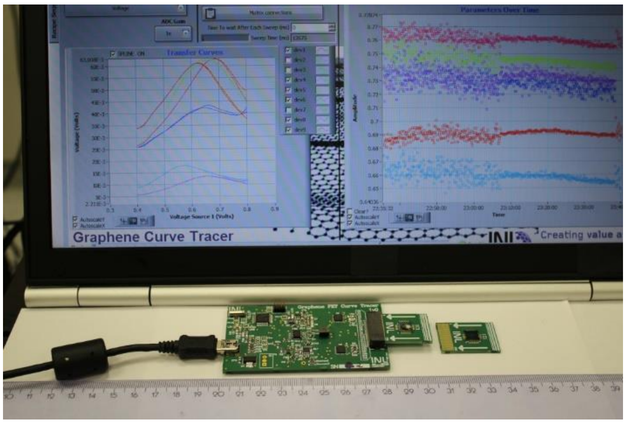

Figure 1: Picture of the measurement system.