Lab-on-a-chip platform for detection of DNA hybridization based on graphene field-effect transistors

Pedro Alpuim[1,2]
C.D. Liao[1], J. Rafaela Guerreiro[1], M. Martins[1], A.C. Ucuanjongo[2], P.D. Cabral[1,2], F. Cerqueira[1,2], J. Borme[1]

[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

Lab-on-a-chip (LoC) for the detection of complex diseases and integrated bioanalysis are growing in importance and normally require the detection of multiple targets in an autonomous and portable fashion. Graphene exceptional properties, such as low-dimensionality, high carrier mobility and chemical stability, suggest its use in biosensing platforms, providing both molecular recognition and transduction capabilities. Molecular recognition is achieved by surface functionalization with highly specific molecular probes, e.g. DNA single strands whose nucleotide sequence is complementary to the target sequence. Transduction can be achieved in different ways for different types of devices, but here we focus on graphene electrolytically gated field-effect transistors (EGFETs) that are fabricated at the 200 mm wafer scale. The sensor signal results from the shift of the transistor transfer curve due to local gating of the graphene by the charged molecular species that attach to its surface. Specifically, we will use the position of the charge neutrality point in the EGFET transfer curve, to detect probe-target biorecognition events.
Fabrication at large scale requires a graphene growth technique that lends itself to upscaling, while preserving graphene electronic properties. Chemical Vapor Deposition (CVD) is our choice.
In a standard CVD process, the high density of graphene boundaries will induce carrier scattering, hindering the performance of graphene biosensors. Here, this issue is overcome by growing graphene in a confined graphite space, effectively suppressing Cu sublimation, thus reducing Cu substrate roughness, and decreasing the dendrite-edged graphene grain boundaries by working in a diffusion-limited growth regime. Oxidized Cu foils are utilized due to the lower substrate surface reaction barrier that accelerates the growth rate. Figure 1 clearly shows graphene grains sized over 150 um before coalescence. Since the sensing area of the graphene EGFETs is 25 x 75 um^2 – much smaller than the grain size – the devices can be considered as virtually grain boundary free.
Devices will be tested and benchmarked[1] for detection limit, sensitivity, and SNP discrimination for different surface probe densities in a LoC made of a 22 graphene transistor chip wire-bonded to the printed circuit board. The PCB is inserted in a connector transmitting the signals from/to the integrated control electronics board, connected to the PC via a USB cable (see figure).

References

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

Figures

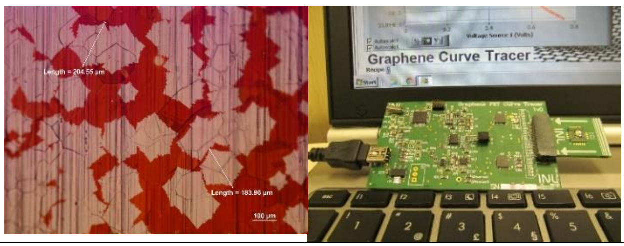

Figure 1: Left: Larger than 150 um grain sized CVD graphene. Right: graphene DUT.