Graphene Biosensors Operated in DC Transistor and AC Electrochemical Modes for DNA sensing

Edgar Pinzón[1,2], Telma Domingues[1,3], Rodrigo Wrege[1], Laís C. Lopes[2], Jérôme Borme[1], Thiago Darós[1], João Piteira[1], Bruno M. Costa[4], Paulo R. Bueno[2], Pedro Alpuim[1,3]

[1]International Iberian Nanotechnology Laboratory, Braga, Portugal
[2]Instituto de Química, Universidade Estadual Paulista, Araraquara, Brasil
[3]Centro de Física das Universidades do Minho e Porto, Universidade do Minho, Braga,
[4]Instituto de Investigação em Ciências da Vida e da Saúde, Escola de Medicina, Universidade do Minho, Braga, Portugal

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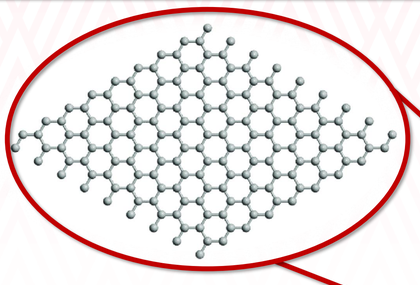
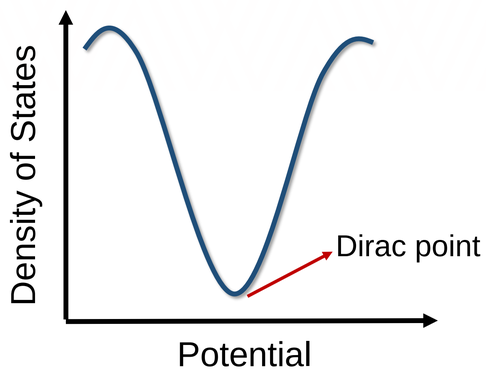
INTRODUCTION (or REQUIREMENTS)

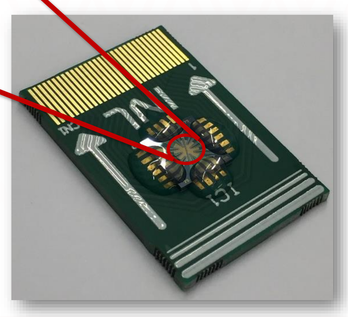
Single layer graphene (SLG)



1.Ambipolar transport
2.Ballistic electron dynamics

Electrical Measurements



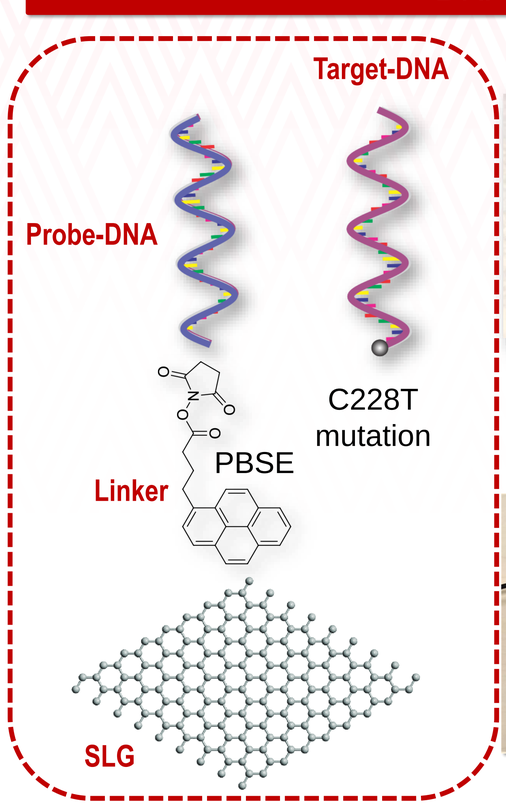


Graphene – device

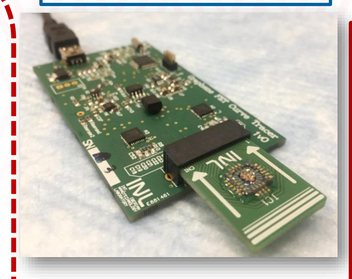
20 channels
(25 X 75 µm)

OBJECTIVES

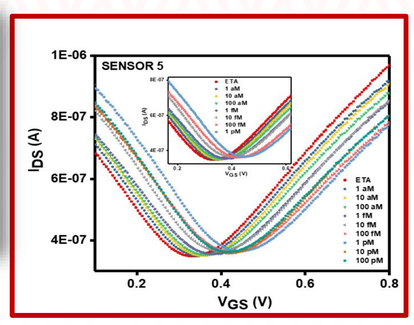
DNA-Biosensing Assays



DC-Setup

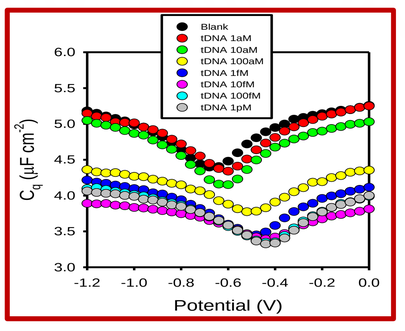


Transfer curve



AC-Setup

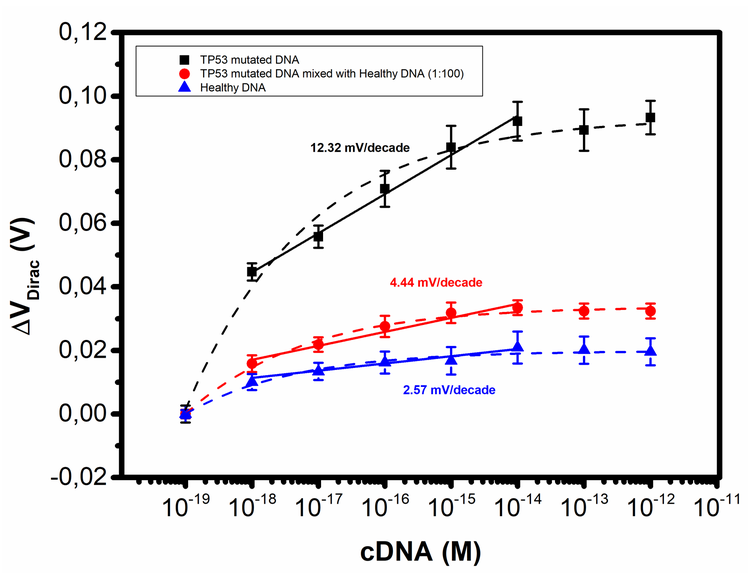
C_q-response



RESULTS

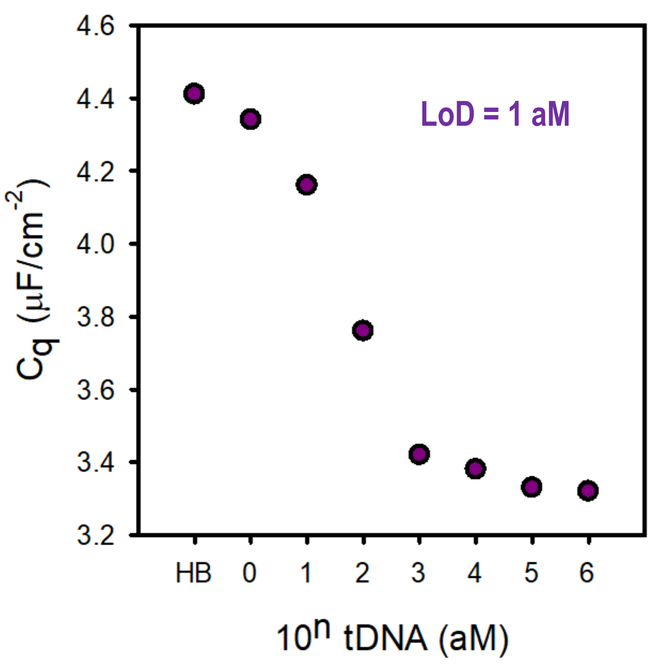
A. DNA-Detection using DC-Transistor Mode

Graphene charge neutrality point shifts (ΔV) as a function of the target DNA concentration (black – **TP53 mutation**, blue – **healthy** DNA, red - **TP53 mutation** mixed with **healthy** DNA in a proportion of 1:100.



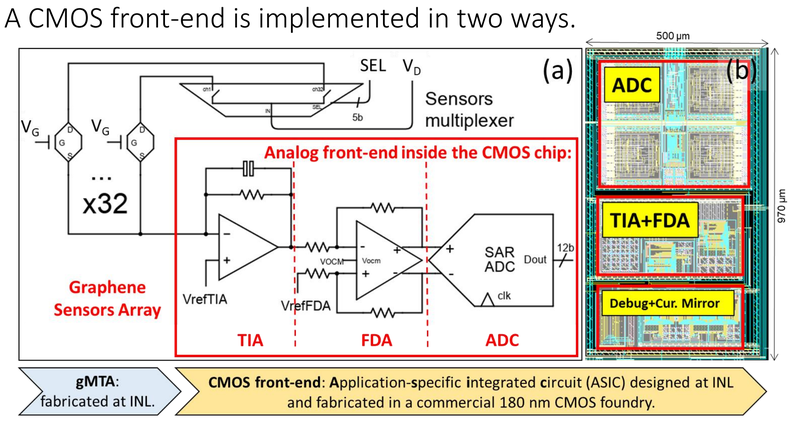
B. DNA–detection using AC-Electrochemical Mode

Quantum capacitance (C_q) response recorded over the graphene biosensor surface by EIS for concentrations of target-DNA (**C288T mutation**) ranging from 1 am to 1 pM.

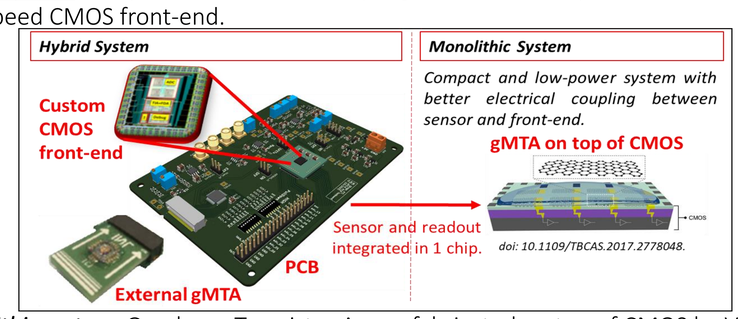


C. A CMOS DC readout for Graphene Transistor Arrays

A CMOS front-end is implemented in two ways.



Hybrid system: Graphene Transistor Arrays (gMTAs) externally connected to a high-speed CMOS front-end.



Monolithic system: Graphene Transistor Arrays fabricated on top of CMOS by VTT.

CONCLUSIONS

1. The graphene liquid-gate transistor transfer curve voltage at the conductance minimum (V_{Dirac}) can be used as a transduction signal to detect and distinguish mutated DNA (TP53 and C228T) from healthy DNA in cancer-related gene sequences.

2. The graphene quantum capacitance (C_q) recorded by AC-electrochemical measurements at its charge neutrality or Dirac point can be used as a transduction signal to detect and quantify DNA sequences.

3. A CMOS readout system consisting of a time-multiplexing of 32 devices at a sampling rate of 10 kS/s per sensor, resulting in a data throughput of 3.84 Mb/s and compromising an area of 970 µm × 500 µm was designed, tested and is under fabrication in commercial 180 nm CMOS technology.

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