Chemical Sensing with Graphene Liquid-Gate Transistors

Pedro Alpuim[1,2], Mafalda Abrantes[1,2], Tiago Pereira[1], Telma Domingues[1,2], Bruno M. Costa[3], João Mouro[1], Luís Jacinto[4], Jérôme Borme[1]
[1]*International Iberian Nanotechnology Laboratory, Braga, Portugal*
[2]*Centro de Física das Universidades do Minho e Porto, Universidade do Minho, Braga, Portugal*
[3]*Instituto de Investigação em Ciências da Vida e da Saúde, Escola de Medicina, Universidade do Minho, Braga, Portugal*
[4]*Experimental Biology Unit, Department of Biomedicine, Faculty of Medicine, University of Porto, Porto, Portugal*
pedro.alpuim@inl.int

Abstract
Biosensing with graphene transistors, with their promising potential, is a significant area of research. Their inherent 2D nature, high carrier field-effect mobility and ambipolar transport, chemical inertness and robustness, and the possibility of surface functionalization make them a compelling choice. The sensing principle – local gating by analyte molecules whenever they attach to the graphene channel – modulates its Fermi energy, causing a shift in the transistor transfer curve, typically detected by measuring the point of minimum conductance [1]. I will show the attomolar detection of single-stranded DNA containing a mutation occurring in brain tumor cells and the results on neurotransmitter detection using a short-strand dopamine-specific DNA aptamer [2]. I'll present DC and AC configurations for the graphene chip interrogation and signal acquisition. Finally, liquid-gate transistors often suffer from electrical instability due to the interaction of their charge carriers with the defects in the surrounding insulator layers [3]. Here, we present a complete model for the observed transfer curve drift based on the electron capture and emission rates from and to the SiO_x defect bands. Once understood, this effect can be controlled, effectively removing the drift in most practical situations.

References

[1] A. Purwidyantri et al., ACS Sens. 8 (2) (2023) 640-654
[2] M. Abrantes et al., Journal of Nanobiotechnology (2022) 20:495
[3] T. Knobloch et al., Nature Electronics, 5 (2022) 356-366

Figures

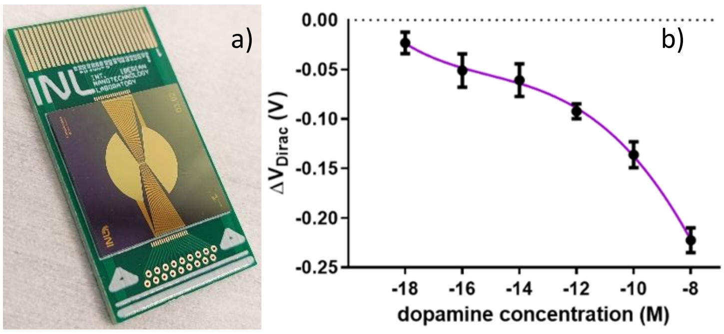

Figure 1: a) Graphene 32-transistor transparent chip for b) dopamine detection in animal model brain homogenates.

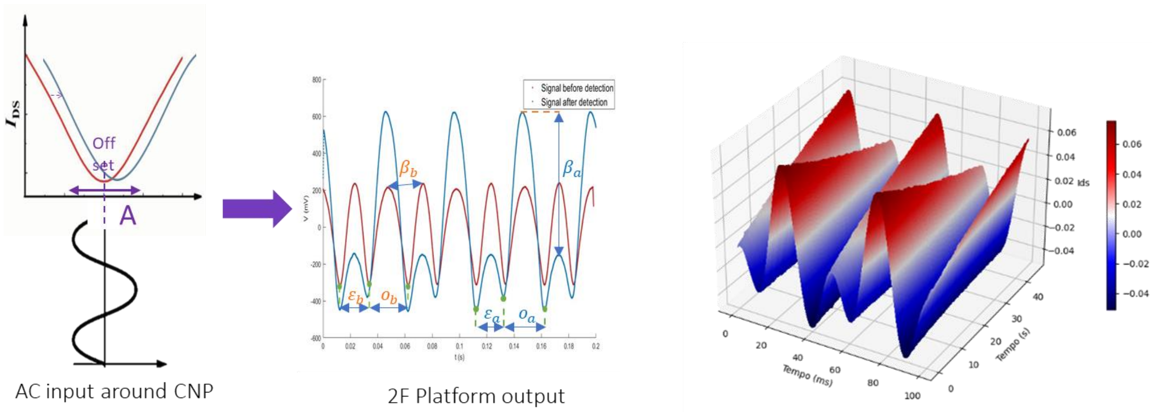

Figure 2: Dopamine detection in an opto-evoked animal model in AC f/2f mode: the transistor polarized at the CNP is a frequency doubler. The signal is the distortion in the 2f output as local gating shifts the polarization away from CNP.