Frequency response evaluation of graphene-electrolyte interface in solution gated transistors

Leo Salgado [a]

Anna Graf [b], Xavi Illa [a,c], Antonio P. Pérez-Marín [b], Rosa Villa [a,c], Jose A. Garrido [b], Sergi Brosel-Oliu [a], Gemma Gabriel [a,c], Anton Guimerà-Brunet [a,c]

[a] *Institute of Microelectronics of Barcelona (IMB-CNM), Carrer dels Til·lers (UAB Campus), Bellaterra, Spain*

[b] *Catalan Institute of Nanoscience and Nanotechnology (ICN2), UAB Campus, Bellaterra, Spain*

[c] *Biomedical Research Networking Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Calle Monforte de Lemos 3-5, Madrid, Spain*

leo.salgado@csic.es

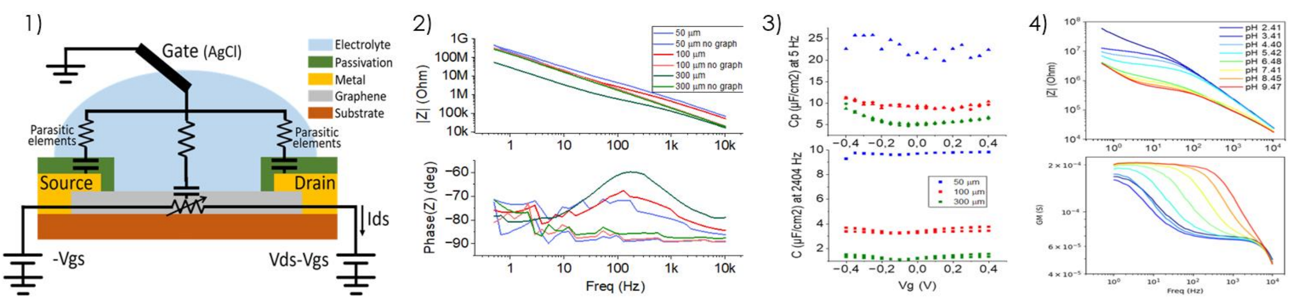
Graphene-based solution-gated field-effect transistor (gSGFET) (fig. 1) is gaining importance in biomedical technologies. For its application, is crucial a better knowledge of the graphene-electrolyte interface behaviour [1]. This interface can be affected by several factors, modifying the performance of the final device. In a first approach, it can be modelled as a capacitance (C_{int}), which is inversely proportional to the area of the transistor channel [2]. This limits its direct observation below certain sizes, mainly due to parasitic effects on connecting tracks. Here we have fabricated independent gSGFETs of varying sizes (50x50, 100x100 and 300x300 µm) to measure both the electrochemical impedance spectroscopy (EIS) for direct evaluation of the interfacial capacitance, and the transistors electrical characterization to study the field effect coupling through the C_{int}, by analysing the transconductance (GM) frequency response. Even though we expected a constant capacitive behaviour over frequency, EIS results show two different capacitive responses separated by a resistive transition (fig. 2 and 3). Also, this same behaviour was observed for the GM results, where two clearly different gains appear at the same frequencies due to these two different coupling capacities, even at smaller gSGFETs, where the EIS is limited by the parasitic effects. Finally, in both approaches it was observed that the frequency transition depends on pH (fig. 4), prompting the hypothesis that this phenomenon could be linked to some interaction with the terminal groups of the SiO_2 substrate of the gSGFETs. All these results prove that the adoption of GM frequency response is a valuable tool for characterizing the C_{int} in small fabricated devices. Data obtained with this approach will be extremely useful for identifying fabrication interferents and improving the calibration method for analysing biological data obtained with gSGFETs.

References

[1] R. Garcia-Cortadella et al., Small, 16 (2020) 1906640

[2] E. Masvidal-Codina et al., Nature Mater., 18 (2019) 280-288

Figures



Figures: 1) Schematics of gSGFET characterization. 2) EIS of several gSGFETs of different sizes. 3) Extracted C_{int} from EIS for the different transistor sizes. 4) Measurement of EIS (top) and GM frequency response (bottom) under a pH sweep of the electrolyte for a 300x300 transistor.