Electrochemical characterization of graphene gated field effect transistors: route for smart biological sensors

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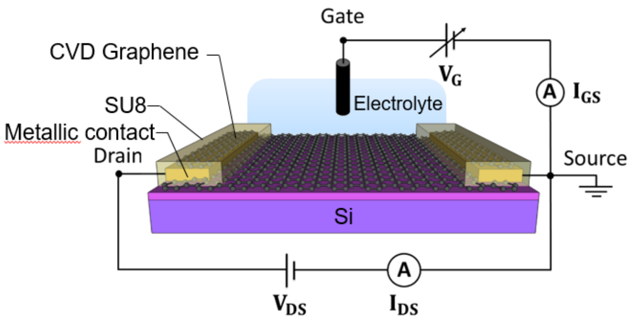
Highly conductive, lightweight, flexible, transparent, mechanically robust, CVD graphene has sparkled large interest in the biosensors community. Indeed graphene ultimate surface-to-volume ratio, associated with exceptional electron mobility is particularly appealing for the detection of charged biological species. Previous work in our group demonstrated a unique fabrication protocol for Graphene Solution Gated Field Effect Transistor (SGFET) on silicium substrates (Figure1). This study first introduces an extended electrochemical characterization of these devices exploring their limits in robustness. Next, results from our first biological detection campaign are presented. In Phosphate Buffer Saline (PBS) 0.01X, V_{GS} was swept from -0.25V to 0.25V with a scan rate of 0,01V/s to characterize the I_{DS} vs. V_{GS} evolution. Graphene was functionalized with either positively or negatively charged proteins. A unique tripodal molecular compound was immobilized on the graphene surface to support a biotin probe [1]. Consecutively, avidin-class proteins were specifically captured on the sensor [2]. Post Data processing gave us access to leakage current evolution, sensitivity of the sensor and V_{Dirac} evolution. Figure 2 shows the obtained responses of the graphene transistors I_{DS} vs. V_{GS} after injection of the different biological molecules involved in our experiment. The direction and magnitude of the shift of the Dirac peak from one functionalization/recognition step to another helps at understanding the inner mechanisms involved in the modification of the electrical double layer at the interface between graphene and the liquid media and their influence on graphene conductivity.

References

[1] J. A. Mann et al., Angew. Chem. Int. Ed. 11, 2013, "Preservation of antibody selectivity on graphene by conjugation to a tripod monolayer".
[2] T. Alava et al., Anal. Chem., 2013, "Control of the Graphene–Protein Interface Is Required To Preserve Adsorbed Protein Function".

Figures

Figure 1: Principle of liquid gating of a graphene transistor.



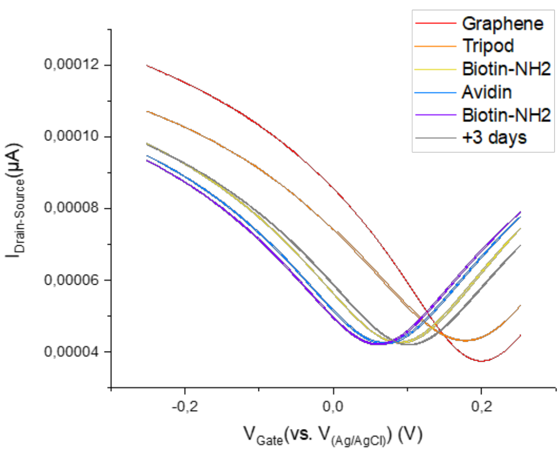


Figure 2: I_{DS}-V_{GS} curves through functionalization/ recognition steps at SGFET.