Tripod-based non-covalent functionalization of highly sensitive graphene SGFET biosensors

Adrien Hugo[1]
Madhav Kumar[1], Riadh Othmen[2], Julien Renard[2], Vincent Bouchiat[2], Chao Sun[5], Jason A. Mann[5], Jeevak M. Parpia[3], Harold G. Craighead[4], William R. Dichtel[5], Pascal Mailley[1], Thomas Alava[1]
1: Univ. Grenoble Alpes, CEA, LETI, F-38000 Grenoble France
2: Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France
3: Department of Physics, Cornell University, Ithaca, New York 14853, USA
4: School of Applied and Engineering Physics, Cornell University, Ithaca, New York, 14853, USA
5: Department of Chemistry, Northwestern University, Evanston, Illinois, 60208, USA

Adrien.Hugo@cea.fr

The electrical detection of biomarkers for diagnosing and monitoring diseases requires biosensors with high sensitivity and selectivity. Graphene-based Solution-Gated Field-Effect Transistors (SGFET) (**Fig.1.a)**) have shown superior electrical sensitivity in liquid compared to silicon and diamond-based SGFET **[1]**, owing to the outstanding graphene electrical properties. Specific biosensing requires functionalization of the graphene surface with biological receptors. Simple adsorption of bioreceptors onto graphene is not suitable, as it has been demonstrated to irreversibly denature protein bioreceptors **[2]**. Besides, covalent grafting of chemical moieties to graphene disrupt its honeycomb lattice, resulting in drastically reduced charge carrier mobility. However, aromatic compounds such as pyrene can adsorb onto graphene by π-π stacking without deteriorating its properties. Thus, several teams have reported the immobilization of bioreceptors on graphene using pyrene-based spacer molecules **[3]**. Nevertheless, it has yet to be unambiguously demonstrated that such spacers would prevent their bound bioreceptors from denaturation by stacking on graphene, due to a rotational degree of freedom along the spacer carbon chain (**Fig. 1.b)**). In this study, we report the functionalization of graphene SGFET with a tripodal molecule including three pyrene feet (**Fig. 1.c)**). Such tripodal molecule is 10^3 times more kinetically stable than classical monovalent spacers, and was specifically designed to stably maintain the functional protein bioreceptors away from the graphene surface **[4]**. Micro-fabricated SGFET **[5]** functionalized with the tripod show a reproducible and significant Dirac peak shift. State-of-the-art electrical sensitivity values maintained after tripod immobilization are reported (**Fig.2**). Building upon these promising results, we are currently binding antibodies to the tripod-functionalized SGFET, and assessing the sensitivity of immunological sensing with our biosensors in buffer-engineered media.

References

[1] L. H. Hess et al., Proc. IEEE 7 (2013) 1780.
[2] T. Alava et al., Anal. Chem. 5 (2013) 2754.
[3] T. S. Sreeprasad et al., Small 3 (2013) 341.
[4] J. A. Mann et al., Angew. Chem. Int. Ed. 11 (2013) 3177.
[5] A. Hugo et al., EDM2018, Grenoble (2018)

Figures

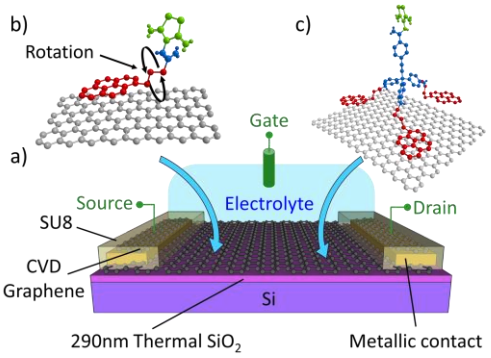

Figure 1: a) SGFET, 3D view of b) monovalent pyrene-based spacer and the rotational degree of freedom, c) Tripod with the pyrene feet (red), backbone (blue), reactive ester group (green)

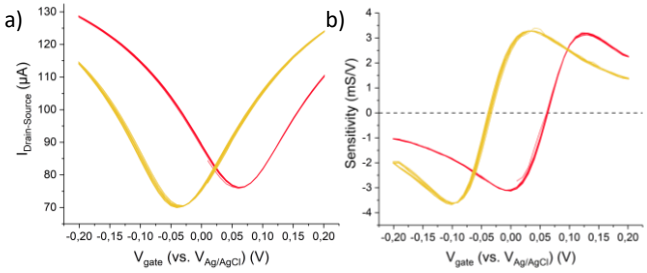

Figure 2: a) Transfer curves and b) sensitivity before (red) and after (yellow) graphene functionalization with the tripod (5 cyclic scans)