Graphene immuno-transistor with femtomolar detection limit in whole serum

Alexey Tarasov
Nesha M. Andoy
Marcin Filipiak
Daniel Vetter
Oscar Gutierrez-Sanz

BioMed X Innovation Center, Im Neuenheimer Feld 515, Heidelberg, Germany

tarasov@bio.mx

Abstract

Purely electronic diagnostic devices that are sensitive to biomolecules' intrinsic charge present a very attractive platform for point-of-care (PoC) applications, since they can operate under label-free conditions [1]. In this report, a graphene-based electrolyte-gated field effect transistor (GFET)[2,3] has been developed as an immunosensor capable of sensitive analyte detection, even in the complex environment of physiological samples.

The co-immobilization of an antibody fragment (F(ab')2) and polyethylene glycol (PEG)[4,5] on the graphene surface allowed for a highly sensitive and specific detection of a protein analyte, with a limit of detection (LoD) in the low-femtomolar range, both in high ionic strength buffer and undiluted serum [3]. Multi-parametric analysis of the device's analyte-dependent electronic response shows that the mechanism behind this very sensitive detection cannot be explained by a commonly reported electrostatic gating effect. Rather, the observed combination of charge neutrality point (CNP) shifts and asymmetric mobility changes are attributed to the modulation of scattering by charged impurities, which seem to dominate the device's transfer characteristics. Furthermore, the reproducibility of the normalized signal response obtained from several different devices show that this graphene-based immunosensor is capable of direct and quantitative measurements of protein analytes in untreated serum, imperative for diagnostic tools geared towards PoC applications.

References

[1] A. Zhang and C.M. Lieber, *Chem. Rev.* 116, 215 (2016)
[2] A. Tarasov et al., *2D Materials* 2, 044008 (2015)
[3] N. Andoy et al., *Adv. Funct. Mater.*, submitted
[4] O. Gutierrez-Sanz et al. *ACS Sensors* 2, 1278 (2017)
[5] M. Filipiak et al., *Sens. Actuators B: Chem.* 255, 1507 (2018)

Figures

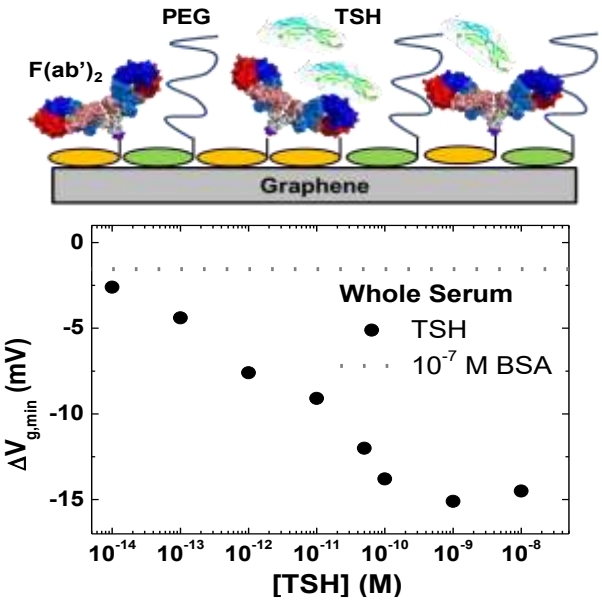

Figure 1: Upper panel schematically shows the surface modification of the device. Lower panel presents the sensor response as a function of the analyte concentration in whole serum (analyte: TSH, thyroid stimulating hormone; circles. control: BSA, bovine serum albumin; dashed line)