Substrate Influence on the pH Response of Graphene-Based Field-Effect Transistors

David Kaiser[1], Christof Neumann[1], Zian Tang[1], Maria Küllmer[1], Daniel Hüger[1], Ugo Sassi[2], Matteo Bruna[2], Ana Ballestar[3], Alberto Garcia[4], Chuz Pérez-Roldán[4], Leopold Georgi[5], Thomas Weimann[6], and Andrey Turchanin[1,7] - *[1]Institute of Physical Chemistry, Friedrich Schiller University Jena, 07743 Jena, Germany, [2]Nokia Bell Labs, CB3 0FA Cambridge, U.K., [3]Graphene Nanotech, 50018 Zaragoza, Spain, [4]IMB-CNM, 08193 Cerdanyola del Valles, Spain, [5]Research Center for Microperipheric Technologies, Technical University of Berlin, 13355 Berlin, Germany, [6]Physikalisch-Technische Bundesanstalt (PTB), 38116 Braunschweig, Germany, [7]Jena Center for Soft Matter, 07743 Jena, Germany,* david.kaiser@uni-jena.de, andrey.turchanin@uni-jena.de

We studied the pH response of solution-gated graphene field-effect transistors (GFETs) microfabricated on SiO_2, poly(ethylene 2,6-naphthalate) (PEN) and SiC substrates. To this end, we employ graphene fabricated by (i) chemical vapor deposition (CVD), (ii) epitaxial graphene on SiC, and (iii) nanoporous graphene.[1] GFETs fabricated on PEN substrates and SiO_2 substrates using CVD graphene were also studied after functionalization with amino-terminated carbon nanomembranes (CNMs).[2] We characterize the shift of the transfer characteristic of the devices in a broad range of pH values from 2 – 12. It has been found that the pH response is enhanced by functionalization with NH_2-CNMs,[3] by increasing the surface number density of chargeable groups on the substrates, by increasing the number density of defects in graphene and by increasing the edge length to surface area ratio of the active device area. The obtained results are compared with model calculations that enable to study the substrate influence on the pH response and to correlate it with the defect number density in graphene obtained from the Raman spectroscopy.

References

[1] C. Neumann, D. Kaiser, M. J. Mohn, M. Füser, N.-E. Weber, O. Reimer, A. Gölzhäuser, T. Weimann, A. Terfort, U. Kaiser, A. Turchanin, ACS NANO 13 (2019) 7310-7322

[2] M. Woszczyna, A. Winter, M. Grothe, S. Wundrack, R. Stosch, T. Weimann, F. Ahlers, A. Turchanin, ADVANCED MATERIALS 26 (2014) 4831-4837

[3] D. Kaiser, Z. Tang, M. Küllmer, C. Neumann, A. Winter, R. Kahle, L. Georgi, T. Weimann, M. Siegmann, S. Gräfe, A. Centeno, A. Zurutuza, A. Turchanin, APPLIED PHYSICS REVIEWS 8 (2021) 031410

Figures

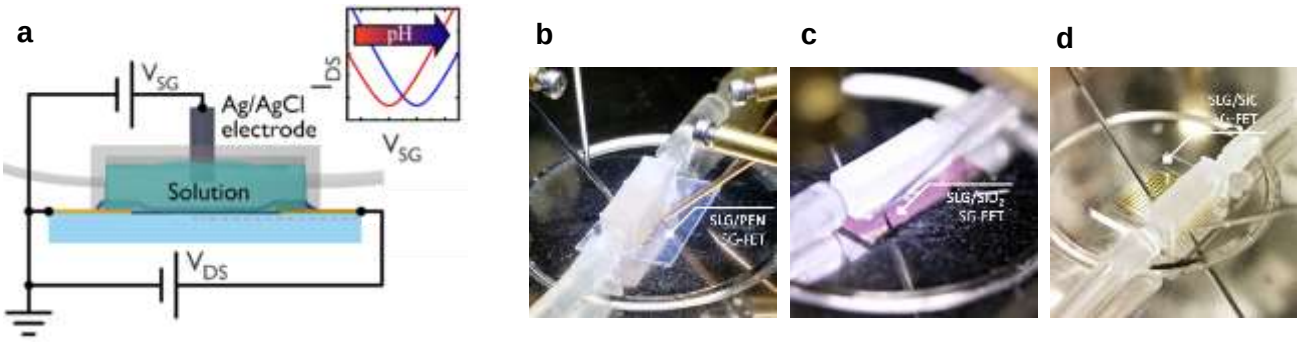

Figure 1: (a) Schematic diagram of the GFET device. (b) An image of the chip with an attached microfluidic channel on a CVD-SLG/PEN device. Probe needles are contacting the source and drain. (c, d) Similar images of GFET devices fabricated on SiO_2 and SiC substrates.