Electrolytic phototransistor based on graphene-MoS2 van der Waals p-n heterojunction with tunable photoresponse

Hugo Henck[1]
Debora Pierucci[1], Zeineb Ben Aziza[1], Julien Chaste[1], Emmanuel Lhuilier[2], and Abdelkarim Ouerghi[1]

[1] *Centre de Nanosciences et de Nanotechnologies (C2N), Route de Nozay, 91460 Marcoussis, France*
[2] *Institut des Nanosciences de Paris, UPMC-CNRS UMR 7588, 4 place Jussieu, boîte courrier 840, 75252 Paris cedex 05, France*

abdelkarim.ouerghi@lpn.cnrs.fr

Van der Waals heterostructures (vdW) obtained by stacking 2D materials offer a promising route for next generation devices by combining different unique properties in completely new artificial materials [1–4]. In particular, vdW heterostructures combine high mobility and optical properties that can be exploited for optoelectronic devices [5]. We propose an approach for the fabrication of a p-n junction based on intrinsic n doped MoS_2 and p doped bilayer graphene hybrid interfaces. We demonstrate the control of the photoconduction properties using electrolytic gating which ensures a low bias operation. We show that by finely choosing the doping value of each layer, the photoconductive properties of the hybrid system can be engineered to achieve magnitude and sign control of the photocurrent. To understand the photoresponse of the system we use a combination of photoluminescence (PL), angle-resolved photoemission (ARPES) and ultraviolet photoemission (UPS) to probe the electronic structure and band alignment of the heterojunction. We additionally demonstrate that the magnitude and sign of the photoresponse can be controlled with Fermi level tunning. Finally, we provide a simple phase diagram relating the photoconductive behavior with the chosen doping, which we believe can be very useful for the future design of van der Waals based photodetectors.

References

[1] D. Pierucci, H. Henck, C. H. Naylor, H. Sediri, E. Lhuillier, A. Balan, J. E. Rault, Y. J. Dappe, F. Bertran, P. Le Févre, A. T. C. Johnson, and A. Ouerghi, Sci. Rep. **6**, 26656 (2016).

[2] D. Pierucci, H. Henck, J. Avila, A. Balan, C. H. Naylor, G. Patriarche, Y. J. Dappe, M. G. Silly, F. Sirotti, A. T. C. Johnson, M. C. Asensio, and A. Ouerghi, Nano Lett. **16**, 4054 (2016).

[3] H. Sediri, D. Pierucci, M. Hajlaoui, H. Henck, G. Patriarche, Y. J. Dappe, S. Yuan, B. Toury, R. Belkhou, M. G. Silly, F. Sirotti, M. Boutchich, and A. Ouerghi, Sci. Rep. **5**, 16465 (2015).

[4] Z. Ben Aziza, H. Henck, D. Pierucci, M. G. Silly, E. Lhuillier, G. Patriarche, F. Sirotti, M. Eddrief, and A. Ouerghi, ACS Nano **10**, 9679 (2016).

[5] H. Henck, D. Pierucci, J. Chaste, C. H. Naylor, J. Avila, A. Balan, M. G. Silly, C. Maria, F. Sirotti, A. T. C. Johnson, E. Lhuillier, and A. Ouerghi, Appl. Phys. Lett. **109**, 113103 (2016).