Graphene/Si Schottky diodes

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We fabricate and characterize graphene/Si heterojunctions in different configurations, by extensively studying the voltage and the temperature behaviour of device parameters and optical response. In particular, we demonstrate tunable Schottky barrier height and record photo-responsivity in a new-concept device made of a single-layer CVD graphene transferred onto a matrix of nanotips patterned on n-type Si wafer. The original layout, where nano-sized graphene/Si heterojunctions alternate to graphene areas exposed to the electric field of the Si substrate, which acts both as diode cathode and transistor gate, results in a two-terminal barristor with single-bias control of the Schottky barrier. The nanotip patterning favors light absorption, and the enhancement of the electric field at the tip apex improves photo-charge separation and enables internal gain by impact ionization. These features render the device a photodetector with responsivity comparable or superior to commercial photodiodes. We prove that the multi-junction approach does not add extra-inhomogeneity to the Schottky barrier height distribution. We also introduce a modified phenomenological diode equation, which well describes the experimental I-V characteristics of a graphene/Si diode both in forward and reverse bias.

References

[1] A. Di Bartolomeo, Physics Reports, 606 (2016) 1-58
[2] G. Niu, G. Capellini, F. Hatami, A. Di Bartolomeo, T. Niermann, E. Hameed Hussein, M. A. Schubert, H.-M. Krause, P. Zaumseil, O. Skibitzki, G. Lupina,W. T. Masselink, M. Lehmann, Y.-H. Xie, and T. Schroeder,, ACS Applied Materials and Interfaces, 8 (2016) 26948-26955
[3] A. Di Bartolomeo, F. Giubileo, G. Luongo, L. Iemmo, N. Martucciello, G. Niu, M. Fraschke, O. Skibitzki, T. Schroeder, and G. Lupina, 2D Materials, Issue (2017) page

Figures

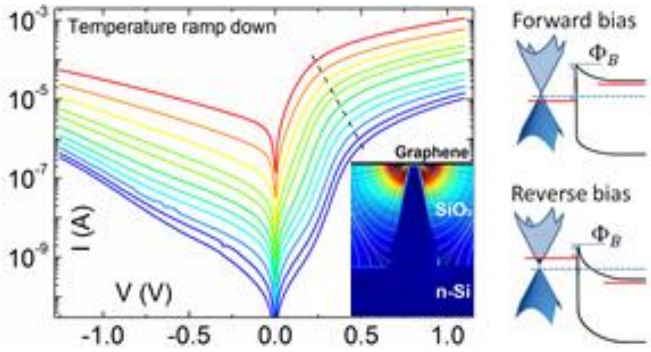

Figure 1: IV characteristics vs. temperature and energy band diagram in forward and reverse bias of a graphene/Si-tip Schottky device (a part of which is shown in the inset).