Graphene Ballistic Rectifiers for THz Rectification

Dr Gregory Auton[1,2]
Dr Dmytro But[3]
Dr Jiawei Zhang[1]
Dr Ernie Hill[2]
Professor Jeremie Torres[3]
Professor Luca Varani[3]
Professor Aimin Song[1]

[1]*School of Electrical and Electronic Engineering, University of Manchester, Sackville Street Building, Manchester, M13 9PL, UK*
[2]*Center for Mesoscience Nanotechnology, School of Computer Science, University of Manchester, Kilburn Building, Oxford Road, Manchester, M13 9PL, UK*
[3]*Institut d'Electronique du Sud, UMR CNRS-UM2 5214, Université Montpellier 2, France*

Gregory.Auton@machester.ac.uk

Rectennas are a combination of both an antenna to absorb RF waves and a rectifier to convert the AC signal into a DC output. They have an exciting range of applications including THz detection and energy harvesting[1]. However, to compete with current technologies a rectifier is required that is both fast enough and sensitive enough. The ballistic rectifier (BR) is a novel device with a very high cut-off frequency [2], a high responsivity and a zero bias voltage threshold making it ideal for such applications. Graphene has the highest mobility of any material at room temperature meaning its use in a BR improves it further. Figure 1 is an atomic force micrograph of a graphene BR where the arrows indicate typical ballistic carrier trajectories; they show that whether the carriers arrive at the source (S) or the drain (D) most of the carriers end up at the lower contact (L) and not the upper contact (U). This means that when an AC field is applied between S and D a DC field is generated between L and U. Using the very latest graphene lithography techniques devices were fabricated with a mobility exceeding 200,000 cm^2/Vs allowing a BR to be fabricated with an intrinsic responsivity as high as 23,000 V/W[3] (see figure 2). Subsequent measurements in conjunction with an antenna have shown no signs of a cut-off frequency up to 700 GHz.

References

[1] E. Donchev *et al.*, MRS E. & Sust., 1 (2014) 1-34
[2] A. Song *et al.*, Jpn. J. Appl. Phys., 40 (2001) L 909 – L 911
[3] G. Auton, Nat. Commun., 7 (2016) 11670

Figures

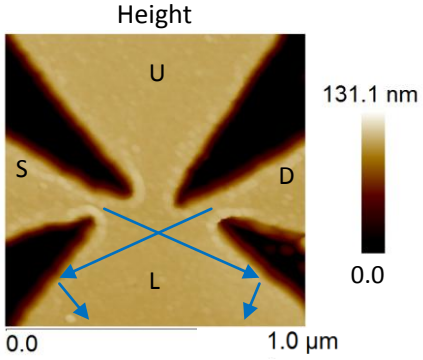

Figure 1: An Atomic-force micrograph of the active region of the circled device has been included to show the geometry of the BR. The arrows indicate typical ballistic carrier trajectories.

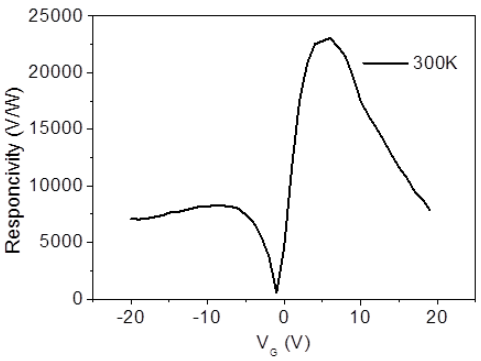

Figure 2: Intrinsic responsivity of the ballistic rectifier as a function of V_G at room temperature.