Graphene Quantum Capacitance in Millimetre-Wave Applications

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Abstract

Quantum capacitance is an inspirational property of graphene that has drawn a lot of attention. In virtue of the low density of states of graphene in a graphene-insulator-metal structure, C_Q demonstrates a wide capacitance tuning range with adequate quality factors [1]. Consequently, C_Q is the main source of nonlinearity in Graphene-Field-Effect-Transistors [1] and graphene diodes [2]. Unlike the conventional Accumulation-mode CMOS varactor in state-of-the-art CMOS technology, C_Q exhibits symmetric C-V characteristics as shown in Figure 1. This unique feature enhance the generation of even harmonics and suppression of the fundamental and other odd harmonics at zero bias and it shows generation of large DC response which explain the excellent responsivity of zero-biased power detectors [3]-[6]. Fabricated graphene varactor in [7] shows the extracted C-V characteristics of C_Q. This distinct C-V properties of CQ allows the employment of graphene in millimetre-wave circuits as frequency doublers and quadrables with adequate conversion gain. In addition, exploiting CQ in parametric circuits allows the implementation of millimetre-wave transceivers with positive conversion gain.

References

[1] J. Xia et al., Nature Nanotechnolgy, 8 (2009) 505.
[2] M. Shaygan, et al., Nanoscale, 33 (2017) 11944.
[3] J. S. Moon et al., IEEE EDL, 33 (2012) 1357.
[4] M. Saeed, et al., IEEE IMS, (2017) 1649.
[5] M. Saeed, et al., IEEE TMTT, 66 (2018) 2018.
[6] M. Saeed, et al., IEEE IMS, (2018) 1519.
[7] M. Saeed, et al., IEEE EDL, 39 (2018) 1104.

Figures

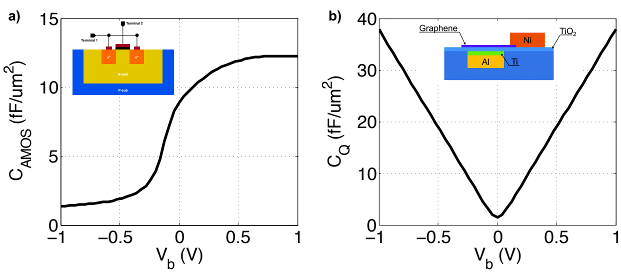

Figure 1: C-V characteristics of a) Acumulation MOS varactor in standard 130nm CMOS technology compared to b) the graphene quantum capacitance.

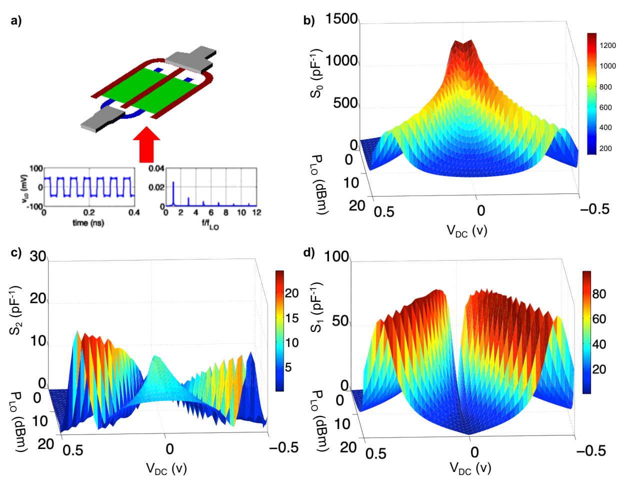

Figure 2: a) Graphene C_Q exited by a local oscillator signal, and the resulting elastance b) S_0, c)S_2, and d)S_1.