Development of Amplifier integrated circuits based on graphene field effect transistors

Wei Wei
Sebastien Fregonese, Di Zhou, Simon Skrzypczak, Reetu Raj Pandey, Emiliano Pallecchi, Henri Happy
University of Lille - IEMN CNRS UMR8520, Avenue Poincaré, CS 60069, 59652 Villeneuve d'Ascq, France
IMS Laboratory, CNRS UMR 5218, Université Bordeaux 1, Talence, France
Wei.wei@univ-lille.fr

Abstract

Flexible electronics has drawn attentions for both research and industry. Applications such as wireless communication for internet of things (IoT) demand high speed, mechanically robust flexible devices. Graphene is still regarded as a promising channel material applied for flexible RF devices. It has excellent electronic and mechanical properties [1,2]. High frequency flexible Graphene field-effect transistors (GFETs) with good mechanical stability have been reported[3]. Transistors are particularly important as they are the core of amplifiers, which are essential part of communication modules. However, for real applications, only transistor is not enough. The transistor fabrication yield, the development of flexible passive componants and their integration with actvie GFETs are also important issues that need to be considered. To date, only a few amplifier measurements or simulations for flexible and rigid graphene technologies have been reported [4-6]. In [4] a high performance and flexible transistors have been characterized in source and load pull configuration to analyze high frequency noise and power gain. The results are impressive but the reference plane is set at the input and the output of the transistor therefore neglecting the losses in the passive elements, which are important in real circuits.
Here we propose a flexible amplifier design based on our graphene transistors and flexible passive components. The transistors were first fabricated on kapton substrate and fully characterized at DC and RF. A substrate bonding free process allowed a relatively high yield of 82%. To demonstrate mechanical robustness, we performed fatigue test that consisted of 1000 times cycling of dynamic bending and verified that graphene quality and device performance before and after fatigue test is maintained. The material quality was assessed by Raman, the performances were derived from S-parameters measurements. Flexible capacitors and inductors were also well developed. Finally, based on our fabricated flexible GFETs and passive elements, an amplifier was designed. The design consist of two LC matching circuits and achieves a 4dB gain at a frequency of 5 GHz, which may be relevant for applications since it cover the lower band of the 5G standard. The impact of transistors variability on the amplifier performances will be also discussed.

References

[1] K. S. Novoselov, V. I. Fal'ko, L. Colombo, P. R. Gellert, M. G. Schwab, K. Kim, Nature, 490 (2012) 192–200.
[2] C. Lee, X. Wei, J. W. Kysar, J. Hone, Science, 321 (2008) 385–388.
[3] W. Wei, E. Pallecchi, S. Haque, S. Borini, V. Avramovic, A. Cente-no, Z. Amaia, H. Happy, Nanoscale, 8 (2016) 14097–14103.
[4] C.-H. Yeh, Y.-W. Lain, Y.-C. Chiu, C.-H. Liao, D. R. Moyano, S. S. H. Hsu, P.W. Chiu, ACSNano, 8 (2014) 7663-7670.
[5] C. Yu, Z. Z. He, Q. B. Liu, X. B. Song, P. Xu, T. T. Han, J. Li , Z. H. Feng, S. J. Cai, IEEE Electron Device Letters, 37 (2016) 684-687.
[6] H. M. Lyu, Q. Lu, Y. L. Huang, T. Ma, J. Y. Zhang, X. M. Wu, Z. P. Yu, W.C. Ren, H.-M. Cheng, H. Q. Wu, H. Qian, Scientific reports, 5 (2015) 17649.