Plasmon Resonances of Terahertz Absorption in nano-patterned Graphene

Lei Du, Gang Chen, Lin Wang, Xiaoshuang Chen, and Wei Lu
National Laboratory of Infrared Physics, Shanghai Institute of Technical Physics, Chinese Academy of Sciences,
500 Yutian Road, 200083 Shanghai, China

***Abstract*—The plasmon resonances in graphene and graphene field effect transistors (GFETs) are investigated by electromagnetic simulations of the behavior of photo-generated carriers with applied bias voltage. Our results show a strong absorption in THz regime in patterned graphene field effect transistor, offering a perspective application in far-infrared photodetectors.**

I. INTRODUCTION

Graphene has emerged as a promising material for optoelectronic applications with ultra-broadband responsivity due to its special two-dimensional system and unique band structure. Its absorption spectrum covers the entire visible to far-infrared range. Recently, by electrically doping patterned graphene arrays with an applied gate voltage, Fang *et al.* [1] observed radical changes in the plasmon energy and strength. They found intense extinction peaks under certain voltage in the sub-THz regime. Additionally, graphene plasmons can be tuned toward higher energies by using other sharps under nanoscale.

In this paper, considering graphene as a carrier sustaining plasmons, we put forward similar nanostructures, taking advantage of the terahertz plasmon enhancement in nanometric graphene. The figure 1(a), (b) are SEM images of nanoimprint template of graphene plasmons area in GFET. Surface plasmon has the unique capability to concentrate light into subwavelength volume, so that we can realize high-performance photodetector at terahertz frequency.

II. RESULTS

Graphene, consisting of perfect 2D single atomic layer, can be used to reach the true scaling limit with the additional advantage of having an electrically tunable optical response, which can be beneficial for the fabrication of metamaterials down to the terahertz regime [2, 3]. To illustrate this mechanism intuitively, we carry out photoelectric simulations for a simple GFET consisting of these mentioned structures. A strong resonance absorption is observed at ~15-25THz regime. Since the surface plasmon in graphene could be tuned by the gate voltage, it predicts broader application than conventional plasmonic materials such as gold and silver. Such device is intended to realize the absorption enhancement by graphene plasmon resonances in terahertz regime. Meanwhile, we can improve the efficiency of terahertz photoelectric detection.

In this work, we prepared nano-patterned graphene with electron beam lithography and nano-imprinting methods followed by dry etching. The formation of patterned graphene sample can be clearly shown under atomic force microscope (this is not shown here as limited room). Our results show a resonance behavior in GFET fabricated with nano-patterned graphene which is promising for potential applications in remote sensing, biomedical science, and many other fields.

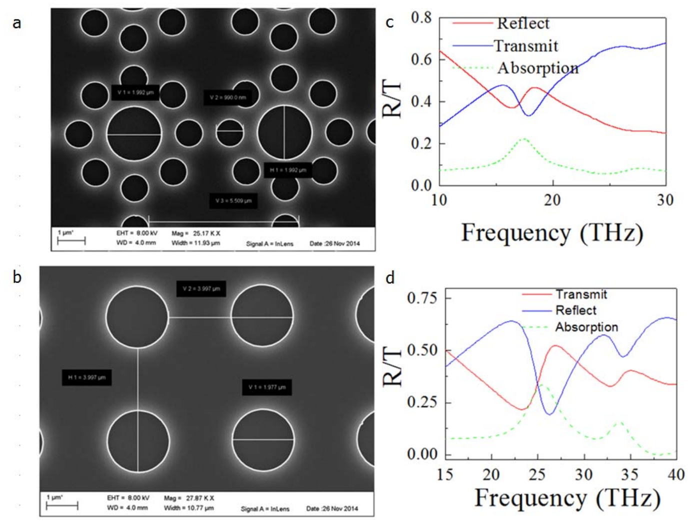

Fig. 1. (a), (b): SEM images of nanoimprint templates of two different configurations for the nano-patterning of graphene plasmons; (c), (d): Simulation results of GFETs fabricated with the nano-patterned graphene with respective configurations.

REFERENCES

[1]. Zheyu Fang, Sukosin Thongrattanasiri, Andrea Schlather, Zheng Liu, Lulu Ma, Yumin Wang, Pulickel M. Ajayan, Peter Nordlander, Naomi J. Halas, F. Javier Garcia de Abajo "Gated Tunability and Hybridization of Localized Plasmons in Nanostructured Graphene," *ACS Nano*, vol. 7, pp. 2388-2395, 2013.
[2]. Lin Wang, Xiaoshuang Chen, Yibin Hu, Shaowei Wang and Wei Lu. "Predictive of the quantum capacitance e□ect on the excitation of plasma waves in graphene transistors with scaling limit," *Nanoscale,* vol. 00, pp. 1-7, 2015.
[3]. Nikitas Papasimakis, Sukosin Thongrattanasiri, Nikolay I Zheludev and FJ Garcı´a de Abajo. "The magnetic response of graphene split-ring metamaterials," Light Sci Appl, vol. 2, pp. 1-4, 2013.