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Theoretical Performance limit of Telecom-wavelength Graphene-Silicon Schottky Photodetector

Abstract : Hot-carrier dynamics and its application in optoelectronics, electronics and energy conversion has been the subject of intensive study [1]. The key in realization of functional hot carrier-based devices is the collection efficiency of hot carrier, apart from generation mechanism. Metal-Semiconductor contact is usually used to extract the excess energy of hot carrier. Previous theoretical work has predicted that the limiting efficiency for hot carrier solar cell based on plasmonic Au-Semiconductor Schottky junction is below 8% under the standard solar spectrum [2], much lower than silicon-based photovoltaic solar cell. In our work [3], instead, we show the limiting efficiency for graphene-semiconductor Schottky junction is about 12%, increased by 4% compared to previous report. With the same structure, we examine the performance of photodetector based on graphene-Si Schottky junction under telecom-wavelength. Results show that the photocurrent responsivity can be larger than 1 A/W at 1.55 um under reverse bias of 1 V, which is much larger than the state-of-art value of 0.37 A/W reported for graphene-Si wave guide structure and comparable to the performance of standard Si/Ge photodetector (0.4-1 A/W). Furthermore, we demonstrate that the noise equivalent power (NEP) can be as low as 10^{-10} W/Hz0.5/m. Finally we identify the physical origins behind the superior performance of device: linear band structure of graphene and unique interface properties. The experimental verification of the model is under way.

References

[1] Harry A. Atwater and Albert Polman, Nature Material 9, 205 (2010).

[2] Thomas P. White and Kylie R. Catchpole, Appl. Phys. Lett. 101, 073905 (2012).

[3] Shi-Jun Liang, et al. In preparation.

Figures

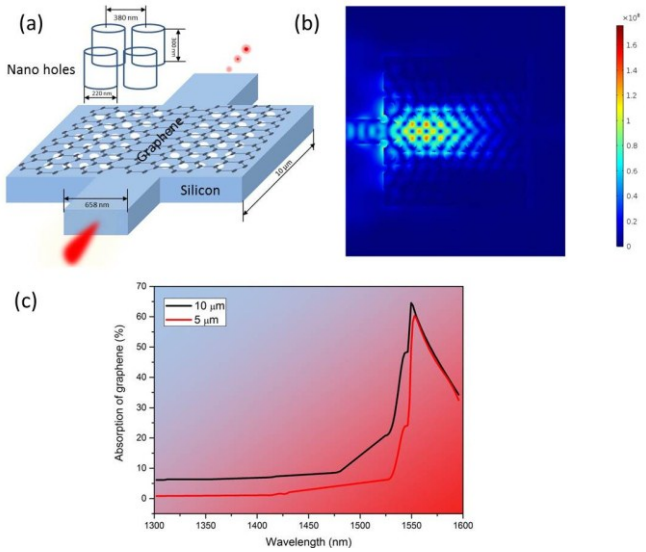

Figure 1: Device setup, electric distribution and absorption of graphene.