High-Frequency Graphene Diodes and Tunnelling Effects

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Abstract

Considering the increased popularity of the Internet of Things (IoT) and Wireless Sensor Networks (WSN), RF energy harvesting (WEH) are in demand [1]. It will be able to recharge and even, in some cases, replace batteries. This will facilitate lightweight wearable devices a reality. The electromagnetic spectrum in 30GHz~3THz range is attracting attention for potential applications. A critical component for the electronic circuitry for these applications is a detector, i.e., a rectifier. Hence, in addition to RF, their DC performance should be quantified for industrial usage. Since the path loss of an EM-far-field strength is inversely proportional to the square of the distance, the threshold voltage of the diodes must be as small as possible. Hence, there is a need for a Schottky barrier diode (SBD), which satisfies these requirements. This device has threshold voltages less than 0.2V. The SBD is operated at zero bias and should be able to rectify the RF signals > 300 GHz with DC output power in μW to mW [2]. Taking advantage of linear dispersion relation of graphene and proximity effect induced breaking down of that symmetry, we experimentally fabricated RF SBDs using CVD grown single layer graphene. Here, Ti and Ni asymmetric metals are patterned using EBL to produce channel lengths 0.5 to 2 μm. The device shows electrical detectivity of 2.5 and intrinsic cut-off frequencies of 300-400 GHz in ambient. The working principle of these devices can be understood using Klien tunnelling effects at high frequency.

References

[1] Luis Portilla et al. Nature Electronics 6 (2023) 10
[2] Dimitra Georgiadou et al. Nature Electronics 3 (2020) 718

Figures

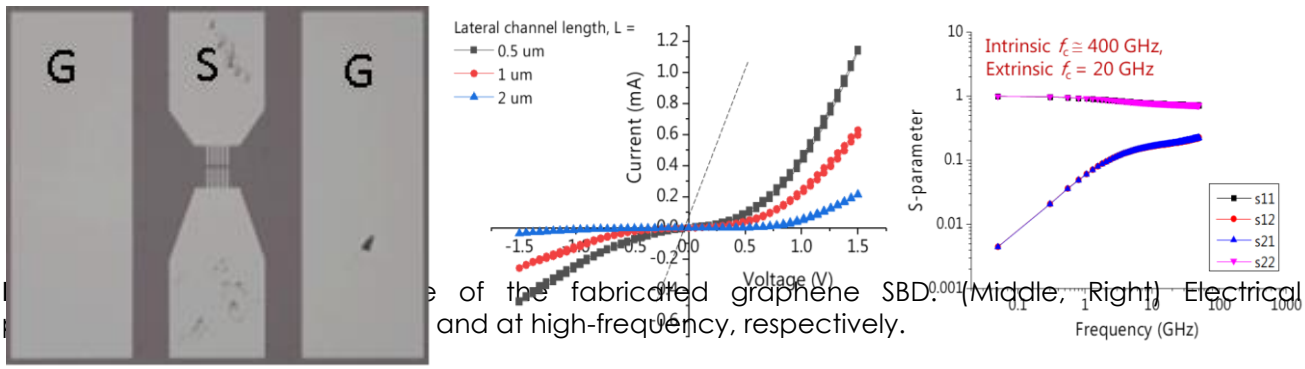

Figure 1: (Left) Optical image of the fabricated graphene SBD. (Middle, Right) Electrical and at high-frequency, respectively.