Study on Graphene based next generation flexible photo-detector for optical communication

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Abstract— We report on the efficient radio wave photo-detection (PD) properties of graphene based p-i-n photo-detector, where all the three layers are either single or multilayer graphene sheets. We report the dependence of 3-dB gain bandwidth, frequency response and responsivity on the i-layer thickness and the total device areas. This simple structure paves the way for the next generation flexible wireless communication systems.

Keywords: Flexible Electronics, Graphene, Photo-detector.

1 Introduction

The next generation flexible and wearable communication systems require efficient radio frequency detector which is compatible with the flexible fabrication process of the devices. In recent years, graphene based photo-detectors have been successfully reported.[1-4] However, most of the fabrication process does not allow the utilization of the devices in flexible systems. Graphene is a zero band gap hexagonal honeycomb carbon atomic layer,[5] which allows electron-hole pair generation in a broad range of wavelengths, from UV, visible, and telecommunication bands to IR and terahertz frequencies.

2 Aim of the study

In this study we report the graphene based p-i-n PD system where all the three layers are fabricated from graphene. This unique structure can easily be fabricated on flexible substrates for wearable applications.

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3 Methods

Let us consider the graphene based p-i-n photo-detector structure, where light is incident on the P side. The structure is comprised of single layer of n+ graphene, an undoped multi-layer graphene and finally a single layer graphene p+ layer. The p and n layers thicknesses are fixed to be 1 nm. The intrinsic layer thickness is varied from 1 nm up to 5 nm. The thickness range has been decided based upon practical fabrication purpose. Mechanical or chemical exfoliation of graphene usually results in few layers of graphene. Expensive and tedious CVD deposition is not preferred. We have also varied the whole device area and analyzed the gain bandwidth and frequency response of the device.

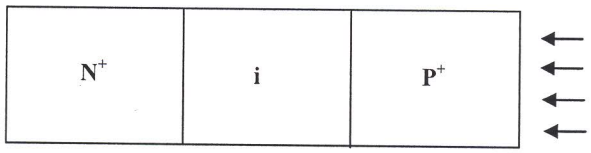

Fig.1 Schematic structure of a graphene based p-i-n photo-detector.

4 Results

Fig. 2 shows the 3-dB gain bandwidth of the device where the i-layer thickness is varied and device area is changed. We observe the maximum bandwidth ($\approx$ 5 GHz) is obtained for the multilayer graphene i-layer. Device dimension also affect the bandwidth values as observed from the plot.

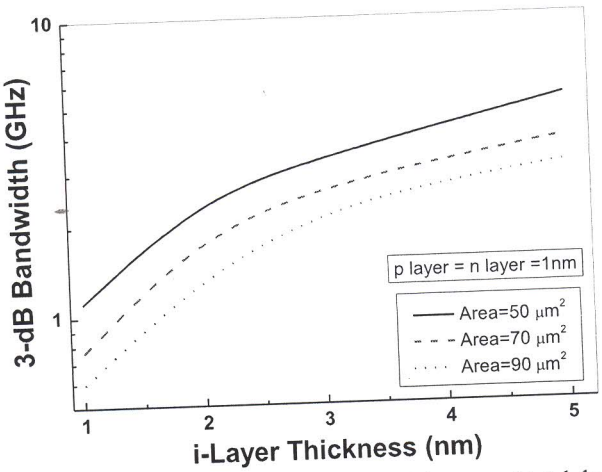

Fig. 2: Change of gain bandwidth with the i-layer thickness and total device areas.

Fig. 3 shows the frequency response plot where the device dimension is fixed at 50 μm^2, which gives rise to maximum bandwidth. Again we observe the multilayer graphene i-layer gives rise to better response. Keeping the i-layer thickness and device area fixed at 5 nm and 50 μm^2, we investigate the responsivity (see Fig. 4) of the PD system to be comparable with the reported values in the literature.[4]

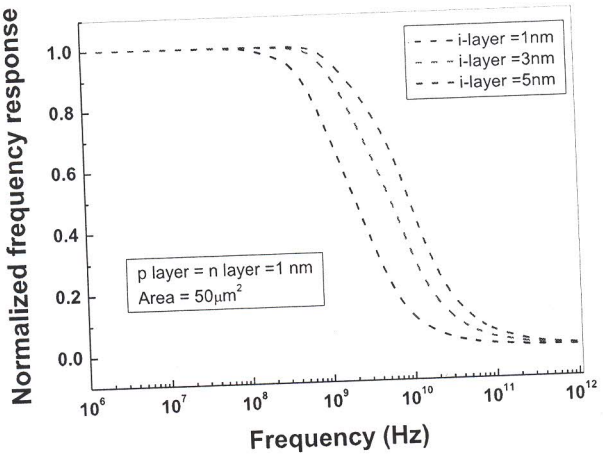

Fig. 3: Variations of normalized frequency response with the i-layer thickness for a fixed device area.

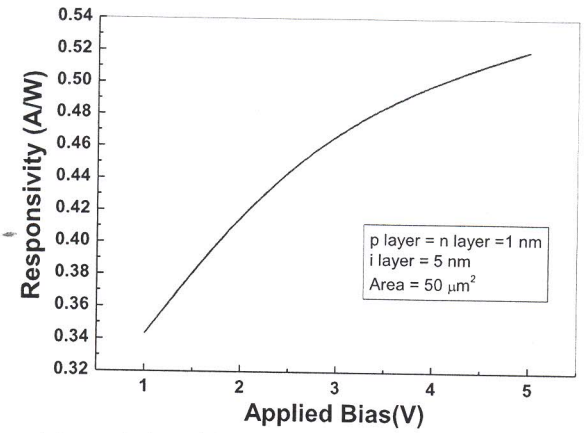

Fig. 4: Responsivity variation of the device.

5 Conclusion

In summary, we have designed an effective graphene based PD system to detect radiofrequency, which can be fabricated on flexible substrates. The PD system can be effectively used in the next generation communication systems.

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