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Graphene Based Frequency Doubler: A Mini Review

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Abstract— Graphene, a thin atomic sheet of carbon atoms has attracted many researchers to explore this wonder material. The unique novel properties combined with the electronic devices has opened many areas of development in the field of electronics and communication. Specifically the highest carrier mobility and saturation velocity in graphene are the most suitable requirements for high speed electronics. Many devices consisting of non-linear components based on graphene are being used. In this paper, graphene frequency doubler is reviewed and their application in electronics and communication is being discussed.

Keywords— Graphene, Silicon, Frequency Doubler, GFET, Ambipolarity,

I. INTRODUCTION

Graphene, a one atom thick layer of carbon atoms is sp^2 hybridised and arranged in a honeycomb lattice [1]. Since it discovery in 2004, the unique electrical and electronics property of graphene has inspired many researchers to work on this material [2]. Till now, the basic non-linear circuits such as the mixers, frequency doublers and many more which were used in electronics and communication was based on the conventional semiconductors materials such as Ge and Si[9]. With the discovery of graphene and its excellent property, these Si based circuits have been replaced by graphene. Graphene being a semiconductor with zero band gap has been used as channel in field effect transistors which is known as graphene field effect transistor which was reported in year 2004. It was first discovered through mechanical exfoliation method for producing graphene flake which was deposited on the top of SiO_2 / Si substrate. Another GFET grown on SiC substrates with an intrinsic frequency f_T = 4.2 GHz and maximum frequency f_{max} of 14 GHz was also reported. Since then GFET as frequency doubler are being used for many applications.

Hence this wonder material has revolutionised the world with its novel electrical and electronic properties [3]. In this paper, we will be discussing particularly the graphene based frequency doubler circuit and their applications.

II. GRAPHENE FREQUENCY DOUBLER CIRCUITS

A frequency doubler generates an output signal whose output frequency is multiple (harmonics) of its input frequency These circuits are the non-linear circuits that distorts the input signal and consequently generates harmonics of the input signal A filter thereafter the frequency doubler circuit removes the unwanted fundamental and other frequencies from the output. These frequency doubler based on Si suffers certain limitations which can be overcome by the using graphene. material in these circuit. Graphene most important property of its ambipolarity makes these circuits more reliable as compared to the conventional circuits [4]. Ambipolarity refers to the property of graphene, which allows the electrons and holes to conduct in alternative half cycles to produce an output signal whose fundamental frequency is twice that of input. An ambipolar GFET frequency doubler is as shown in figure 1[5].

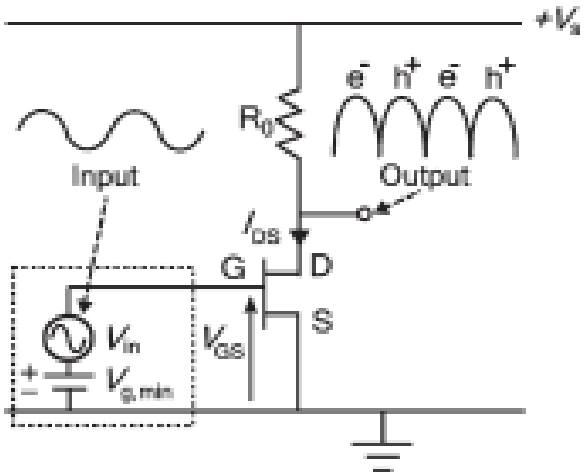

Figure 1: GFET frequency doubler circuit

In this GFET frequency doubler circuit, the gate is biased to minimum conduction point and a sinusoidal input is superimposed on the gate terminal .It is seen that in such a device, the fundamental mode is substantially attenuated at the maximum power of second harmonic. Hence this device achieves high spectral purity without any filter circuit at the output. Research reports a GFET frequency doubler circuit gives more than 90 % of the converting efficiency in contrast to conventional systems [6]. Another GFET frequency doubler circuit is reported. It generates an output signal of 40 MHz when an input of 20 MHz is given This device shows a high spectral purity in the output radio frequency signal where 93% of the output radio frequency energy is at fundamental frequency of 40 MHz.

III. ADVANTAGES OF GFET FREQUENCY DOUBLERS OVER CONVENTIONAL FREQUENCY DOUBLERS

A. Signal Noise:

Conventional frequency divider circuits produce noisy signals that require filter circuit in the output but graphene frequency divider produces a clean output signal without a filter at the output.

B. Power Consumption:

Conventional frequency doubler consume a lot of power because of size but graphene frequency doubler consist of single transistor and thus are compact and consume less power

IV. APPLICATIONS OF GFET FREQUENCY DOUBLER CIRCUITS [6,7,8]

These frequency doubler circuits are used in variety of communication applications.Some of the common are mentioned below:

A. *Digital and Analog Communication*
B. *Radio Astronomy*
C. *Terahertz Sensing*
D. *Imaging*

V. CONCLUSION

This paper gave a mini review of the GFET based frequency doubler circuit. With the combination of novel properties of graphene and the electronic circuit of frequency doubler, the GFET frequency doubler has emerged as an excellent device, which is replacing conventional Si, based circuits. The ambipolarity, which in combination to high carrier mobility are responsible for high-speed electronics. Apart from the application in electronics and communication, it is also integral part of other systems. Research in the area of graphene is still on and efforts are made further to enhance its use in future electronics.

REFERENCES

[1] K.S.Novoselov et al “Electric Field Effect inAtomically Thin Carbon Films,”Science vol 306,2004
[2] Geim, A. K. et al. “The rise of graphene”, Nature Mater, vol. 6, pp.183–191,2007.
[3] Neto A., Guinea F. et al, “The electronic properties of graphene,” Rev. Mod. Phys.,vol. 81, No. 1, pp. 109–162, 2009.
[4] Wang, Han et al. “Graphene-Based Ambipolar RF Mixers.” IEEE Electron Device Letters, vol. 31, pp. 906-908, 2010.
[5] Han et al. “Graphene Frequency Multipliers.” IEEE Electron Device Letters, vol. 30, No. 5, 2009.
[6] Habibpour, Omid, et al. "A subharmonic graphene FET mixer." Electron Device Letters, IEEE, vol. 33, pp. 71-73, 2012.
[7] Camargo E., “Design of FET Frequency Multipliers and Harmonic Oscillators”. Norwood, MA: Artech House, 1998.
[8] Palacios, T. et al. “Applications of graphene devices in RF communications”. IEEE Communications. Mag. 48, pp. 122–128, 2010.
[9] Han, Shu-Jen, et al. "High-frequency graphene voltage amplifier." Nano letters , vol. 11, pp. 3690-3693, 2011.

