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Graphene Based Terahertz Antenna Design for Modern Applications

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ABSTRACT
In the Modern communication field, transmitting data through compact antennas like Microstrip patch antennas plays a major role. For Mobile radiolocation, satellite services, medical applications at Terahertz frequency range. Designing antennas for such applications at this frequency must have less weight and good characteristics. For this, graphene is the best suitable material for design due to its electrical, optical, and thermal conductivity properties. So, The Graphene-Based drilled substrate patch antenna 500 X 500 X 40 µm presents the simulation in the terahertz frequency. The prosed antenna structure is well suitable in the ISM (Industrial Scientific and Medical) band 1.36 THz-1.64THz 2.4 ~ 2.5 GHz. Its gives a high gain -20dB. Their Properties have been analyzed with CST for full-wave Simulations.

Keywords
Nano di-patch antenna, Graphene, THz Antenna, Modern Applications

1. INTRODUCTION
The development of technology the number of wireless devices increases rapidly which leads to data traffic [1]. Many applications like banking, education have the demand from desktop version to mobile version; it leads to band width problems & data traffic. In the future by 2035, the data rates likely to reach Gbps or Tbps [2-3]. The dominant solution for high traffic is choosing the frequency band that is not allocated [4]. Which is Thz EM wave spectrum falls between microwave and infrared light? According to WRC (world radio communication conference) held in 2019, the frequency range from 275-450 GHz is allotted for fixed and land mobile services. So, the Thz communication system has got more attention for researchers & scientists. At present, the Thz reads the Gbps data rate and, it can further have extended to Tbps by polarization multiplexing [5-6]. The Graphene based patch antenna is shown in the figure 1. According to IEEE standard, The Thz EM waves in between 0.3 and 10Thz with a wavelength of 0.003mm to 1mm. The Graphene patch antenna schematic diagram, characteristics and units in Thz domain are shown in the fig.1, Table.1 &2 respectively.
The graphene two dimensional carbon crystal stacking of layers [7]. L. Zakrajsek, et al. described the graphene nano-antenna working accuracy in detailed way [8]. The polarization behaviour of graphene is reported in [9]. The graphene has unique properties for making nano-patch antennas in which all the dimensions are in micrometers. It has the lower dielectric loss, good radiation mechanism and higher tuning efficiently at Terahertz frequency range [10]. Saber et al. proposed reflector array with frequency adjustment based on graphene [11]
Graphene has more advantages than metals like silver, gold etc. larger propagation lengths, lower losses, high thermal & electrical conductivity including dynamic control characteristics.

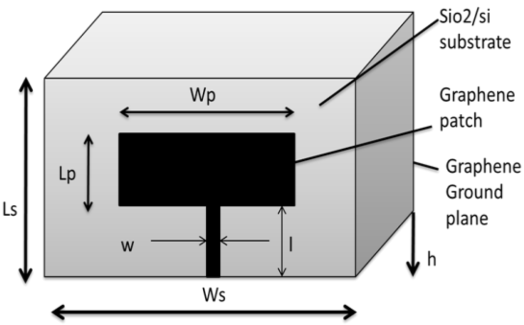


Figure 1: Structure of Graphene Patch Antenna

Table 1: Characteristics of Graphene

Characteristics	Description
Photon Energy	It is less than the x-rays. So don't harm the human tissue. Used in body scan, bio-medical, cancer treatment applications.
Wide bandwidth	It occupies highest frequency band. The Thz wave as a carrier support high data rates even Tbps.
Visualization /Penetrate	Due to short wavelength, it can penetrate through non-metallic objects and provide higher definition images.
Spectral resolution	The most of the spectrum occupied with Thz wave. So, the radiation has significance for detecting various goods.

The Table II indicates the units of parameters in Terahertz domain. These are considered for 1st to 4th of frequency ranges from 0.3 Thz to 30 Thz and respective wavelengths $\lambda = \frac{c}{f}$ where $c = 3\times10^{8}$ m/sec. is mentioned in micro meters, temperature and energies are shown.

Table 2: Different Units in Terahertz Domain

Parameter	1st	2nd	3rd	4th
Frequency (Thz)	0.3	3	10	30
Wavelength (µm)	1000	100	30	10
Temperature (K)	14.40	144.0	479.30	1440.20
Energy $E = meV$	1.240	12.41	41.30	124.10

µ=10-6 K, T means Tear 1012E=KBT where KB is Boltzmann's Constant.

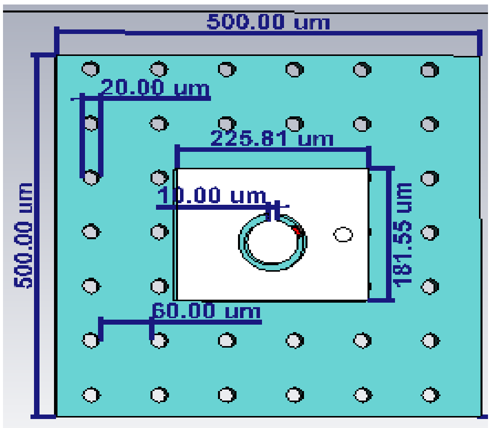


Figure 2: Geometry of the proposed antenna

The Table III shows the Geometrical dimensions of the proposed antenna in micro meters. The substrate is the graphene material and patch is the silicon lossy. The respective top view along with dimensions is shown in figure 2.

Table 3: Dimensions of The Proposed Antenna

Particular	Dimension	Dimension Units (µm)
Substrate (Graphene)	Length/width	500
	Height	40
Patch (Silicon Lossy)	Width	225.81
	Length	181.55
	Height	40
Substrate(circle)	Radius	20
Two Circles (sub)	distance	60
Patch ring width	Outer radius	40
	Inner radius	30
	Open width	10

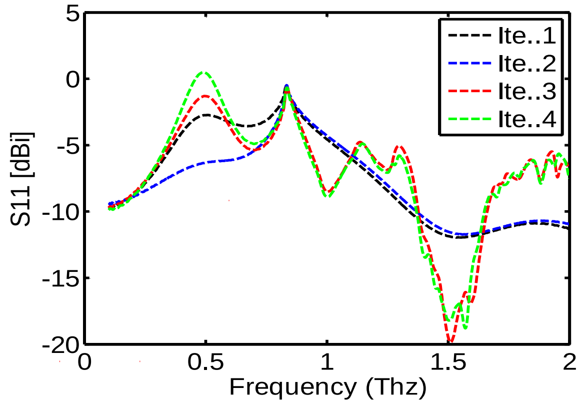
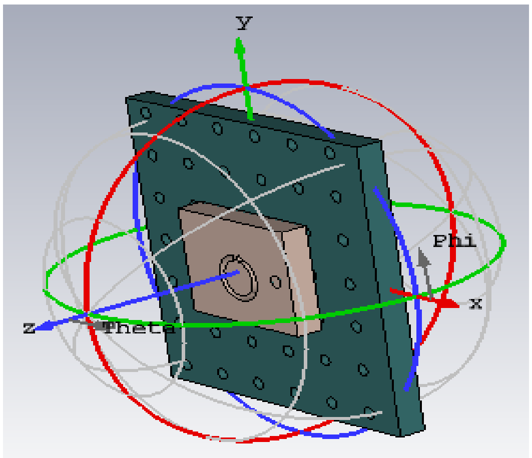


Figure 3: The simulation of return loss of graphene antenna for four iterations

The simulated return loss curves incorporated in one plot is shown in Fig 3. For four iterations in which the first two iterations fall below -10dB at 1.3Thz and gets almost overlapped. The 3rd and 4th iterations form a bandwidth 1.3 to 1.6Thz with good gain. The spherical view in conjunction with cartesian coordinates of proposed antenna is shown in figure 4 (a).



(a)

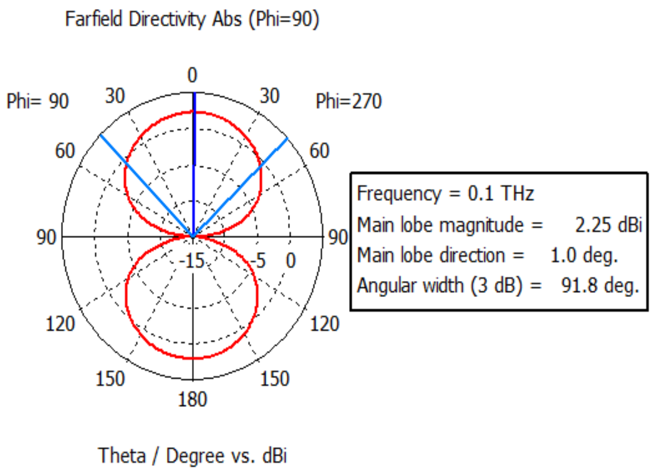


Figure 4: Fairfield Radiation pattern (a) Fairfield cuts with design part (b) Fairfield Directivity at 0.1Thz (c)at 1.05Tz and (d) 2Thz.

The Far-field dimension cuts for the proposed antenna is shown in the figure (a) followed by farfield patterns Degree Vs. dBi is shown in the fig (b-d) for the frequencies 0.1, 1.05 & 2 THz

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respectively. At 0.1 Thz dumbbell shape pattern is obtained in the directions 00 and 1800 with zero sidelobes. For the frequencies 1.05 & 2 Thz the sidelobe levels are getting decreased from -5.8dB to -3.0dB.

2. CONCLUSION

In this paper, graphene-based Terahertz antenna characteristics are studied. The graphene used for obtaining better characteristics. The obtained operating frequency at Terahertz suitable for modern applications. In future, explore the simulated and fabricated results further on this antenna prototype to design patch antenna arrays for terahertz communications. This work can be enhanced further to series and parallel or array for tuneable purpose.

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