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Analysis of Graphene Based Dielectric Resonator Antenna (DRA)

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ABSTRACT: This paper represents a study of a Graphene based Dielectric Resonator Antenna (DRA) Antenna. In recent years Dielectric Resonator antenna is been playing a key role for wireless service requirements. Many structures of DRA have been applied to certain areas as it offers various benefits such as no inherent conductor loss, simpler coupling and the advantage of being lightweight. In this project we will be dealing with a conical shaped DRA with a coating of graphene and a micro strip technique to gain its enhanced features in different applications of ultra-wide band.

KEYWORDS: Dielectric Resonator Antenna (DRA), Graphene, Microstrip feeding, Application.

INTRODUCTION

Antenna is one of the most important part of wireless communication systems. There have been many changes in the design of an antenna due to the constant advancements that keep on occurring in the field of wireless communication system. Currently, the design of THz Antenna is in major demand because they provide a higher data transfer rate. But metal coated antenna have the major disadvantage of bad conductivity at high frequency which causes degradation of the radiation efficiency. So, to overcome our limitation, we are using graphene-based DRA. While a dielectric resonator antenna comes with a lot of advantages like a wide bandwidth and low loss, Graphene also has many unique electronic properties.

Graphene contains a single layer of carbon atoms, and its structure is in the form of honeycomb lattice It has a very unique 2D structure and basically, the horizontal dimension can be extended whereas thickness remains in atomic scale. When we put this material in a 3d structure, it starts exhibiting a very high specific surface area and a low density. Also, graphene has many electrical powers - one of them being its good carrier mobility. Its band structure is also good enough for it to be used in radio frequency circuits [1]. The reason we chose graphene for our project was because graphene in itself has a very unique structure wherein the movement of electrons happen with less resistance. This makes it a better suitable option than metal which can become lossy at high frequencies [2]. Our Antenna can be used for future 5G applications as well as for detecting cancerous cells in the body.

DESIGN OF ANTENNA

Our antenna consists of substrate made up of silicon dioxide (SiO_2) which has relative permittivity, $\varepsilon_s = 2.1$ and loss tangent $\tan\delta = 0.003$. Our ground plane has dimensions $h_l \times w$. A Silver (Ag) film which has a height hf is deposited over the substrate of height hs1 so as to form the feedline structure.

The dimension of our nanostrip feedline $l_f \times w_f \times h_f$. Our DR made up of polysilicon and has a relative permittivity of $\varepsilon_r = 11.56$ as well as dimensions $a \times b \times h_2$ in its geometry. Our feedline helps in providing an excitation to this DR [3-9]. In our antenna, we have used polysilicon-based DR having the height h_2 and a partial graphene coating on the top of the DR. Our DR has been put over a thin layer of substrate which has the height h_2 Graphene material has been partially coated on the surface of upper DR. The dimensions that we have used are in μ_m. These dimensions are as follows:

$l = w = 50$, $a = b = 12$, $l_f = 25$, $s = 1.5$, $w_f = 3$, $hf = 0.2$, $h_1 = 1.6$, $h_2 = 4.4$, $l_s = w_s = 12$, $w_g = 10$, $h_g = 0.05$, $a \times b \times h = 10$ (dimensions in μ_m). In our antenna, we have considered $Vo = 0$, $t = 1$ nm and $\varepsilon_r = 3.8$. Our relaxation time is 0.5 ps and the temperature has been set at T=300K.

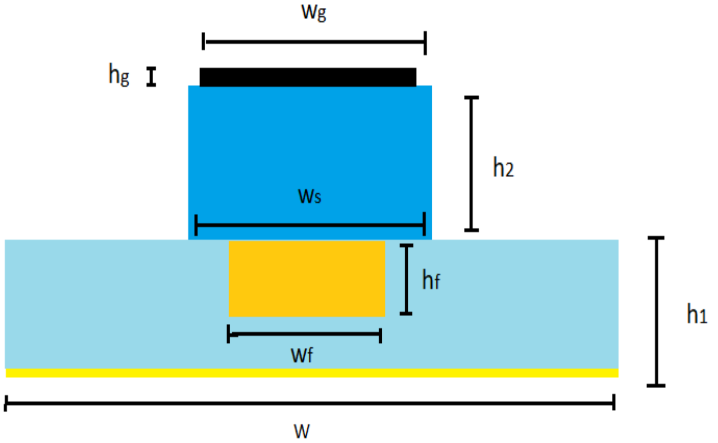

Figure 1(a): Geometrical layout of proposed antenna

Table 1: Graphene based DRA Antenna Dimensions

Parameter	Value in (μm)
W	50
h1	1.6
Wf	3
hf	0.2
Ws	12
h2	4.4
Wg	10
hg	0.05

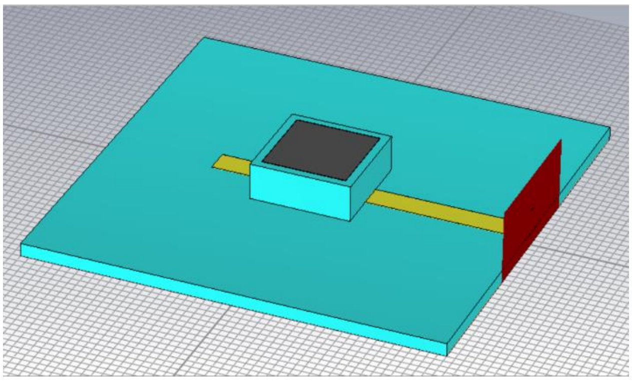

Figure 1(b): Structure of proposed antenna

RESULT AND DISCUSSION

CST microwave studio software, has been used for the design of antenna and it has been checked for various parameters.

S_{11} Parameter

S_{11} parameter is one of the most important parameters for the analysis of antenna. The scattering parameter which is known as S-parameter represents that how much power is reflected from the antenna and it is known as the reflection coefficient [10-15]. If the value of S11 parameter is zero (0 dB) then all the power generated, is reflected from the antenna and nothing is radiated and if it is -10dB this indicates that if 3 dB of power is delivered to the antenna than -7 dB is the reflected power. As we know antennas are typically designed to be low loss ideally so the majority of the power which is delivered to the antenna gets radiated. From figure 2, we have observed that for the frequency bandwidth form 8 THz to 15 THz the value of S_{11} parameter is -24.8dB.

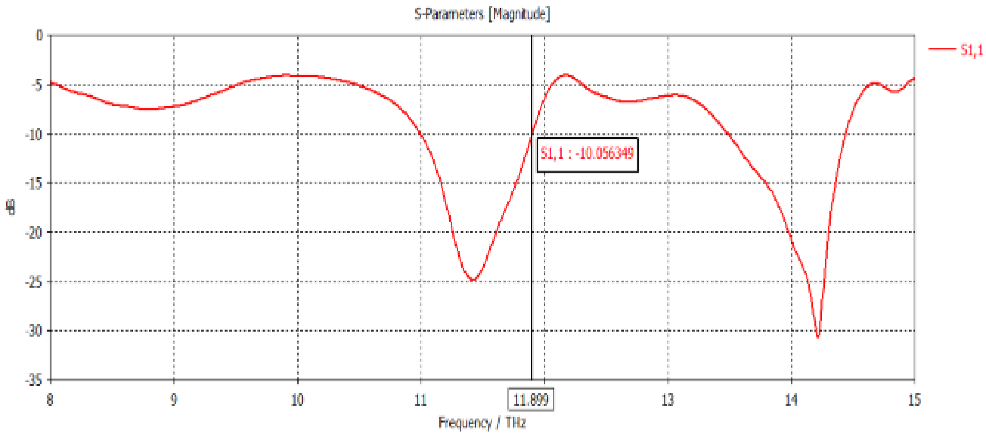

Figure 2: S_{11} parameter plot

VSWR Plot

Voltage standing wave ratio, ie, VSWR is known as the ratio of the maximum voltage to the minimum voltage that is in a standing wave pattern which is along the length of a transmission line structure.

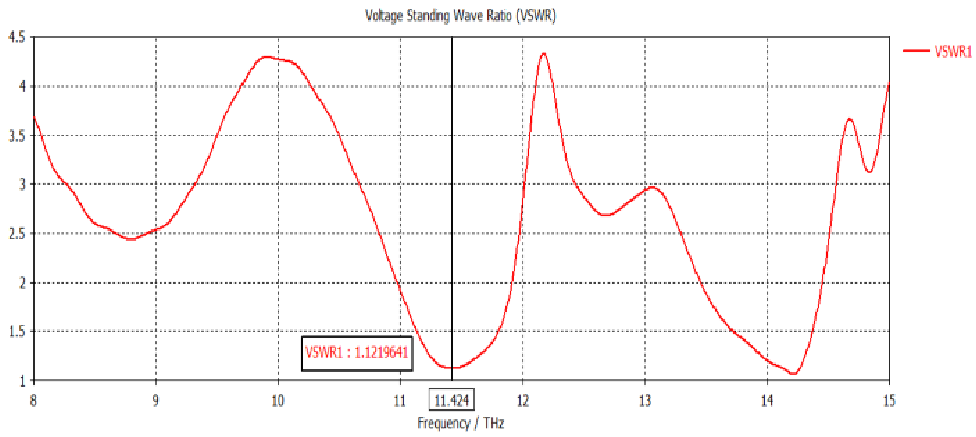

Figure 3: VSWR plot

It varies from 1 to ∞ and always remains positive. Unless there is a piece of slotted line-test equipment, this may seem like a hard definition to follow, mostly because the concept of voltage in a microwave structure can have many interpretations. For any radio to provide that kind of power to antenna, its impedance and transmission line need to be very well matched to the impedance of that antenna.

Form figure 3, we conclude that proposed antenna has a VSWR value of 1.1 dB at resonant frequency 8-15THz.

$$VSWR = \frac{V_{max}}{V_{min}}$$

Radiation Pattern

The most crucial part of antenna is the radiation pattern. It tells us about the orientation and gain of any antenna [16-19]. In other words, the antenna's radiation qualities as a function of space, represented graphically in Fig:4 In this section we get to know about the radiated energy of the antenna, 2D and 3D radiation pattern, Fig 4 represents the 2D radiation pattern at frequency 8THz at Φ=90deg and Fig 5, shows the 3D radiation pattern.

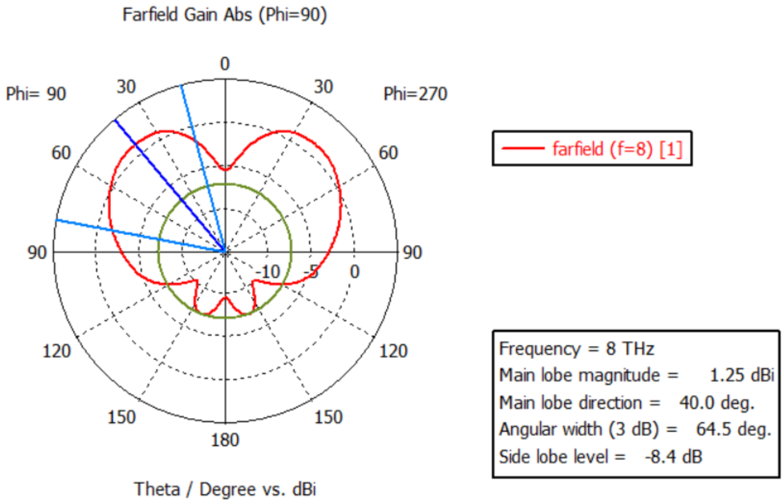

Figure 4: Radiation pattern of the proposed antenna at 8 THz which is evaluated at the Φ=90deg. for all values of θ.

Table 2: Result Analysis of the simulated antenna

Performance parameter	Value
S11(dB)	-24.8
Gain (dB)	5.97
Input Impedance (Ohm)	59.82
VSWR (dB)	1.1
Bandwidth (THz)	8

APPLICATIONS

1. For detecting cancerous cell in the human body
2. UV tracking patch
3. For 5G applications
4. Gas detector and air sniffers
5. Cryo-cooler compressor for 5G
6. For Biomedical & Biosensor

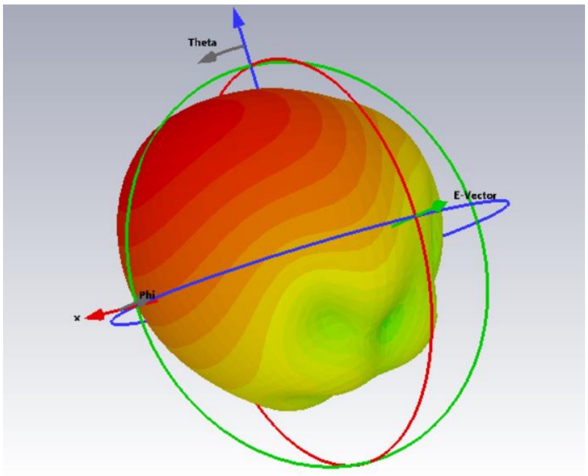

Figure 5: Simulated 3D radiation pattern

CONCLUSION

This paper provides the evaluate on different execution done within the subject of dielectric resonator antenna. After cautiously reading these research papers and one-of-a-kind experimentations finished on DRA, we are able to see that through deciding on proper strategies, editing feed geometry structure of DRA, we can easily increase the bandwidth. The variation of different parameters of the antenna which have an effect on the working area and operation of the antenna had been studied [19-22]. With every new research there was an attempt to make a progress in this field. While reading these, we saw that a DRA with a metal coating faces many disadvantages which we believe can be eradicated by coating it with graphene. There seems to be a need for nano-antennas needed for upcoming technology and graphene is the best option for that.

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