Graphene Based Archimedean Spiral Antenna For Terahertz Frequency

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Abstract: In this paper graphene based an ultra wideband (UWB) double sided right hand circular polarized Archimedean spiral antenna operating with a chip resistor load. The double slide Spiral patch is fabricated on gallium Arsenide(GaAs) substrate and its center fed using Surface mount Connector (SMA). Radiation properties and input resistance of same antenna is simulated in Ansys HFSS Software. Normally in Terahertz antenna Gold, graphene or carbon nanotube(CMT) is used. In this paper, A graphene based antenna is designed for frequency range of 1 THz to 10 THz and operating 7.6 THz

Keywords: Terahertz, Graphene, Archimedean spiral antenna, Ultra-wideband, HFSS

I. INTRODUCTION

The gap between microwave and optical frequency band, Terahertz band is represented. This band has significantly high importance in applications like bio-medical military and security. But for this frequency range high gain antennas is major problem. For high gain antenna, spiral antenna is one the best solution. In Archimedean spiral antenna circular layer print on dielectric material. in double sided Archimedean spiral antenna there are two circular layer of conducting material placed either on left hand side or right hand side on non- Conducting material like FR4, GaAs. According material property conducting material is used. For Terahertz Frequency band there are some specific materials are only allow transmitting circular patch. Normally Gold, Graphene and Carbon nanotube(CNT) are used in terahertz communication where graphene is prefer to use. Graphite is composed of single layer of crystalline carbon atoms in hexagonal planner crystal structure. Graphene have some special electro-Optical properties due to which it used in terahertz communication. In graphene we can control it's conductivity by adjusting its chemical potential, by Appling DC electric field or doping.

This paper will introduce, right hand double layer of graphene strips antenna. These two layers are placed on GaAs substrate. The inner radius *r1* and outer radius *r2* are 35 µm and 39 µm respectively and number of turn n= 3. The outer radius of antenna is 3λ where λ is plasmonic wavelength at 0.8 THz. Between these two graphene layer there is an SMA connecter is used to feed. The input resistance is 50Ω. The simulation performed in Ansys HFSS software.

II. ELECTROMAGNETIC PROPERTIES OF GRAPHENE

Intraband conductivity and Interband conductivty are the two parts of surface electrical conductivity of graphene as a function of frequency[6]:

$$\sigma(\omega) = \sigma_{intra}(\omega) + \sigma_{inter}(\omega) \quad (1)$$

$$\sigma_{intra}(\omega) \approx -j\frac{q_e^2 k_\beta T}{\pi\hbar(\omega - j2\Gamma)} \times \left(\frac{\mu_c}{k_\beta T} + 2\ln(e^{-\mu_c/k_\beta T} + 1)\right) \quad (2)$$

$$\sigma_{inter}(\omega) \approx -j\frac{q_e^2}{4\pi\hbar}\ln\left(\frac{2|\mu_c| - (\omega - j\tau^{-1})\hbar}{2|\mu_c| + (\omega - j\tau^{-1})\hbar}\right) \quad (3)$$

where, $\sigma_{intra}(\omega)$ is intraband conductivity and $\sigma_{inter}(\omega)$ is interband conductivity. chemical potential is stands for μ_c , $\Gamma = 1/2\tau$ and τ is transport relaxation time of electron in graphene lattice. In this paper we considered T=300 K, $\tau = 1$ps and lowerband frequency is less than 8THz.

III. GRAPHENE BASED ARCHIMEDEAN SPIRAL ANTENNA FOR TERAHERTZ FREQUENCY DESIGN

As shown in figure (1), design of graphene based Archimedean spiral antenna for terahertz frequency. In design a rectangular substrate of dimension length x width x height 120x120x30 µm. for this substrate frequently used low temperature grown Gallium Arsenide (GaAs) is used. On substrate thin layer of two layer of graphene is fabricated in Archimedean spiral manner. The inner radius

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r1 of spiral design is 35 µm and outer radius r2 is 39 µm. These both lines are separated by distance of 4 µm and the this distance is given by 'd'. Total turns of spiral lines N=3. Input resistance given to this antenna is 50 Ω. For excitation of antenna SMA connecter is connected between these two spiral lines. The bottom part of substrate is made up of copper layer for grounding to SMA connecter. So in this way we done with the model of the antenna. Then after validating the model in HFSS analyse the all results.

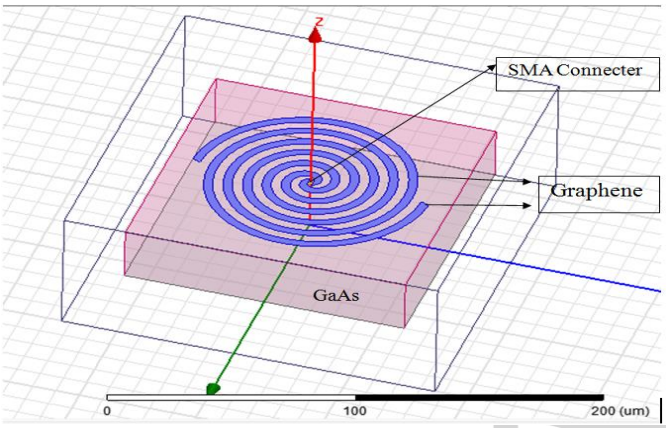

Figure 1: Archimedean Spiral Antenna Design in HFSS

IV. RESULTS ANALYSIS

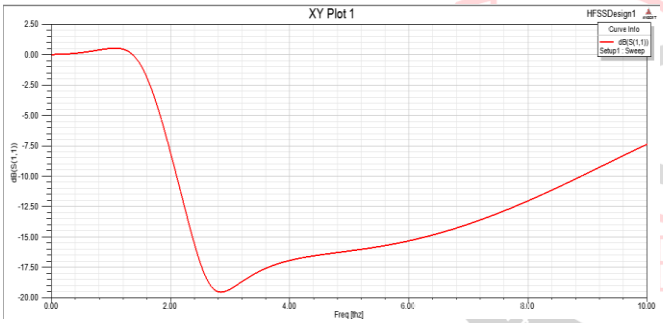

Figure 2: Simulation Result of S11

Figure (2) shows S11 parameter for graphene based THz archimedean antenna which is simulated in HFSS. From this figure it is cleared that S11 is smaller than -10dB when frequency is larger than 2.2 THz.

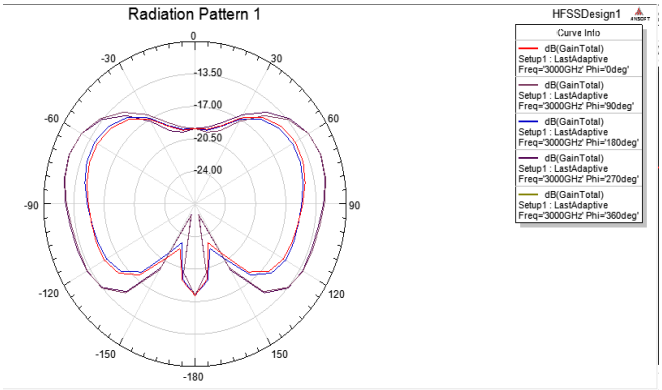

Figure 3: Radiation pattern of Antenna

From figure (3) shows the radiation pattern of same antenna from this figure we can conclude that at frequrncy of 3THz total gain is -19 dBi.

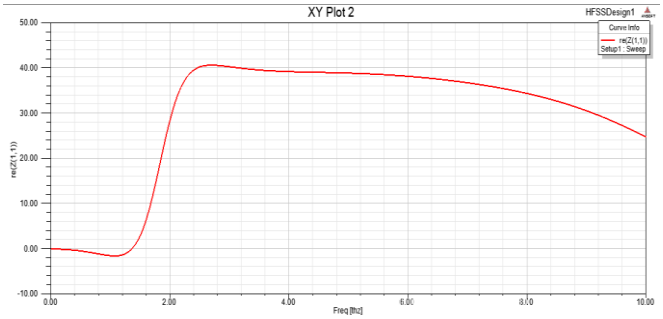

Figure 4: Simulation result of Z11

Figure (4) shows the simulation result of Z11, in this figure impedance plot is almost constant around 40Ω. We design the antenna at input impedance at 50Ω. So we can conclude that input impedance and output impedance is nearly equal so both input and output impedance are matched.

V. CONCLUSION

In this paper, we represented graphene based Archimedean spiral antenna for terahertz frequency waves more effectively in HFSS software. The theoretical and simulated results are closely equal. The main advantage of graphene based antenna is we can increase or decrease the radiated power, only we have to fabricate antenna carefully.

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