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Graphene: A Super Material for the Application of Antennas

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Abstract—*Graphene oxide has a comparative layered structure to graphite, yet the plane of carbon particles in Graphene Oxide is vigorously brightened by oxygen-containing gatherings, which extend the interlayer separate as well as make the atomic thick layers hydrophilic. Thus so forth these oxidized layers can be peeled under moderate Ultra-sonication. If peeled sheets contain only one or few layers of carbon atoms like Graphene, these sheets are named as Graphene oxide. Present work is taking into account modified Hummers' technique for synthesizing Graphene oxide as well as designing and simulating Yagi Uda antenna taking Graphene as a structural material. Yagi-Uda antenna is designed using 3 elements and the results are simulated in the frequency range of 580MHz-600MHz. Upon utilizing parameters, for instance reflection coefficient, reflected power, delivered power and mismatch loss which have been ascertained and plotted against frequency. Topographical study of Graphene oxide was investigated with the help of Scanning Electron Microscopy (SEM).*

Keywords: *Graphene, ImageJ, Reflection coefficient, VSWR, Return Loss, Mismatch Loss, Reflected Power, Bandwidth*

1. INTRODUCTION

Graphene, a flat mono-atomic layer of carbon particles firmly stuffed in a two-dimensional honeycomb grid, has as of late pulled in the consideration of the exploration group because of its novel mechanical, thermal, chemical, electronic and optical properties[1-3]. Its unique band structure is notably being exploited in Nano-electronics to achieve novel high-speed devices such as field effect transistors and frequency multipliers [4-6]. Among these, a particularly promising emerging field is Graphene-enabled antennas. An Antenna is utilized to transmit and get electromagnetic waves. Antenna normally works in air or space, however can likewise be worked or indeed through soil and rock at specific frequencies for short distances [7] .In an antenna framework an electromagnetic wave travels from the transmitter to the receiver through space, and gathering contraptions are required at both completions for the explanation behind coupling the transmitter and the receiver to the space join[8]. A Yagi-Uda Antenna, generally refers to Yagi radio wire or Yagi, is a directional reception apparatus framework comprising of a array of a dipole and extra nearly coupled parasitic components (typically a reflector and one or more directors). The Yagi- Uda antenna is a standout amongst the most splendid antenna designs. It is easy to construct and has a gain typically greater than 10dB. The Yagi - Uda antenna typically operates in the HF to UHF bands (about 3MHz to 3 GHz), although their bandwidth is typically small on the order of a few percent of centre frequency [9].

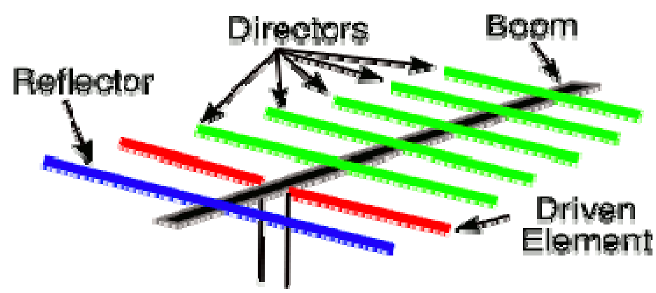

Fig. . 1: Structure of Yagi Uda antenaa with parasitic elements

In this paper we have utilized Modified Hummer's approach to obtain Graphene Oxide (GO) from Graphite. Topographical study of Graphene Oxide was investigated with the help of Scanning Electron Microscopy. By using its high electrical conductivity (10^7 S/m), high electron mobility (2,00,000 $cm^2 V^{-1} s^{-1}$) results[14] ; we have designed and simulated Yagi - Uda antenna using Graphene as a structural material.

2. SYNTHESIS OF GRAPHENE

At present, a conventionally-modified Hummers method is the primary method for preparing GO. Graphite is commonly chosen as the starting material due to its availability and low cost. Proportional amounts of Sodium Nitrate ($NaNO_3$), Potassium Per magnate ($KMnO_4$) as oxidizing agent, concentrated Sulphuric Acid (H_2SO_4) to be mixed with water

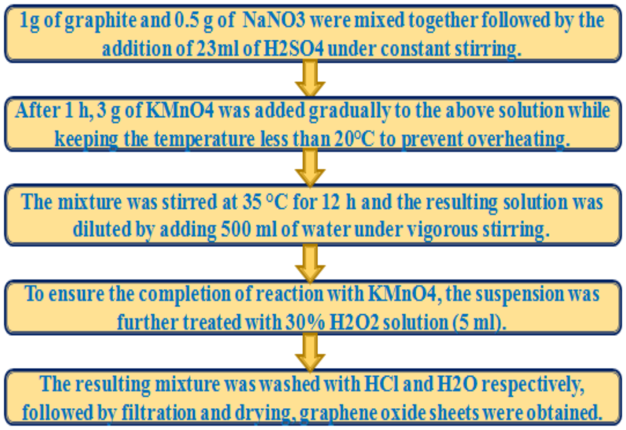

Fig. . 2: Flow chart of Modified Hummers Method used to obtain Graphene Oxide from graphite.

3. CHARACTERIZATION OF GRAPHENE

The samples were characterized using Field Emission Scanning Electron Microscopy (FE SEM) (SUPRA FESEM, with acceleration voltage of 30 kV). Fig. ure 3 shows SEM morphologies of Graphene Oxide which was dried at 80°C for 24hr. As shown in Fig. 3 a two dimensional Graphene sheets can be seen. Fold structure can be found on both the surface and the edges of Graphene Oxide powder**.** The reason for the re-agglomerate may be the long-time high temperature treatment**.** In Fig. 4 the ImageJ programming demonstrates the convergence of the Graphene sheets and the white territory resembles to the Graphene sheets. The thickness of the Graphene sheet is 40nm – 50 nm. 3D profile of the sheets has been plotted to view the Graphene pieces by Image J in Fig. 5.

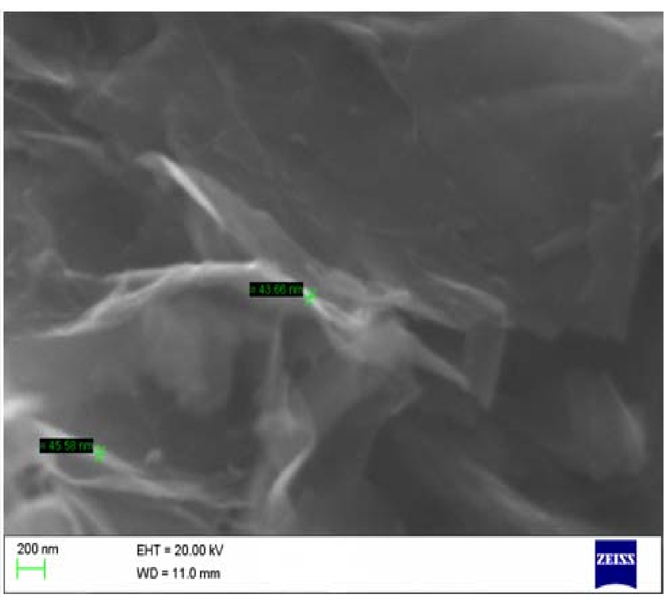

Fig. 3: SEM image of Graphene oxide

Fig. 4: ImageJ pattern of Graphene Sheet

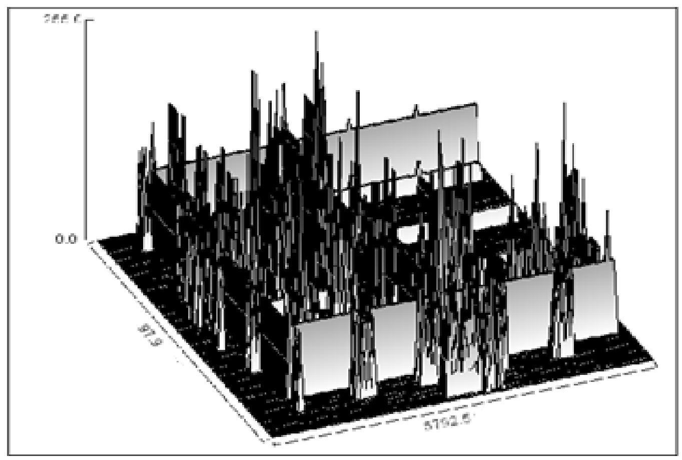

Fig. 5: 3D profile of Graphene Oxide

4. DESIGN AND SIMULATION 0F ANTENNA

4.1 Methodology

The Yagi antenna's basic design is a "resonant" fed dipole with one or more parasitic elements. These parasitic elements are called the "reflector" and the "director." A dipole will be "resonant" when its electrical length is 1/2 of the wavelength of the frequency applied to its feed point. The Yagi-Uda array can be summarized by its performance considering in three parts

a) Reflector
b) Feeder or dipole
c) Director

The length and spacing of the reflector do affect the forward gain but have large effects on the backward gain (F/B ratio) and input impedance (Zin). Thus they can be used to control or optimize antenna parameters. The driven element is typically a λ/2 dipole or folded dipole and is the only member of the structure that is directly excited -electrically connected to the feed-line.[12] All the other elements are considered parasitic. This model represents an antenna appropriate for a single digital terrestrial television. The size we have chosen implies that it resonates around 600 MHz where the wavelength is around 50 cm long, so the stature of our examined space is around one wavelength. As every the recreating programming all the edges of the space being dissected ought to associate with one quarter to one -a large portion of a wavelength from the antenna element. The dielectric layer is air which is taken as 200 mm above and below the antenna element.

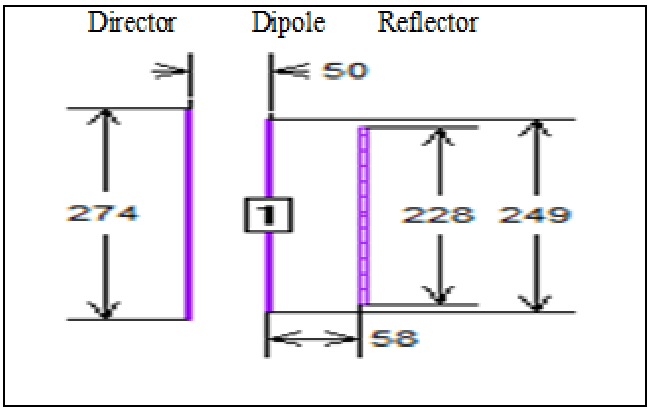

Fig. 6: Arrangement of Yagi Uda Antenna using Graphene as Structural Material

3.2 Simulated Results

We have used only a single port there would be only one S-parameter, S_{11} which is abbreviated as Scattering Parameters. If the incident wave has a voltage magnitude of $a_1$and the reflected wave has a magnitude of b_1 then [11]

Return Loss=20log(b_1/a_1)= -20log[Γ][dB] eq1

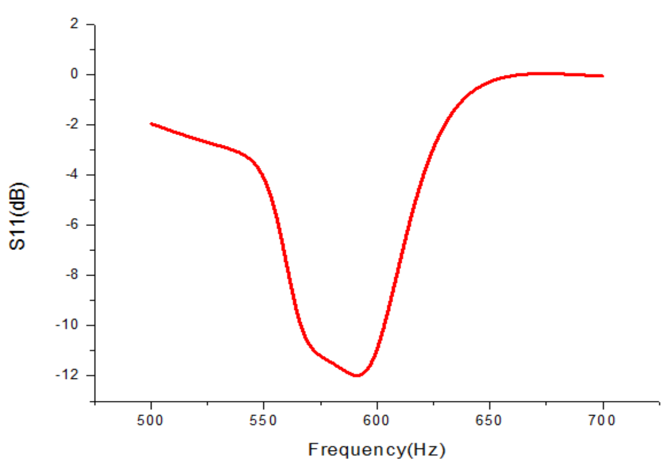

Fig. 8: Graph shows the variation of Reflection coefficient(dB) V/s frequency

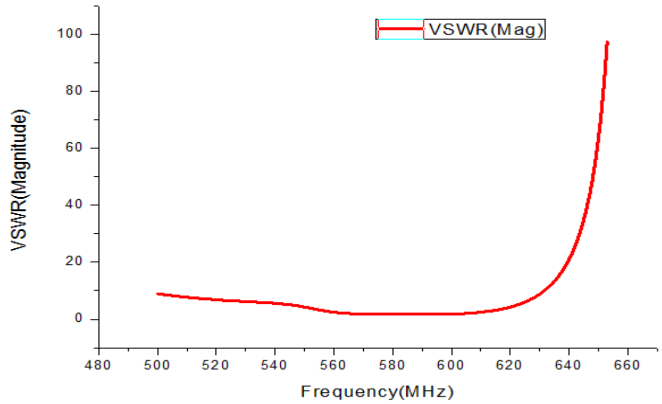

Fig. 9: Graph shows the variation of VSWR Vs frequency

The parameter VSWR is a measure that numerically portrays how well the antenna impedance is matched to the radio or transmission line it is associated with. VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient (Γ), which describes the power reflected from the antenna

Table 1: VSWR values at different frequencies

Freq	570	574	578	586	590	594	598	602
VSWR	1.81	1.76	1.74	1.69	1.67	1.68	1.73	1.86

$(\Gamma) = (VSWR - 1) / (VSWR + 1)$ eq 2 Reflected Power(%)=100 X Γ^2 eq 3 Reflected Power (dB) = 20 log (Γ) eq 4 Delivered Power (τ) = $1 - \Gamma^2$ eq 5 Mismatch loss (dB) = 20 log (τ^2) eq 6

Fig. 9 show the variation of VSWR with frequency and the values are tabulated in Table1.The value of VSWR is 1.67 at 590 MHz.

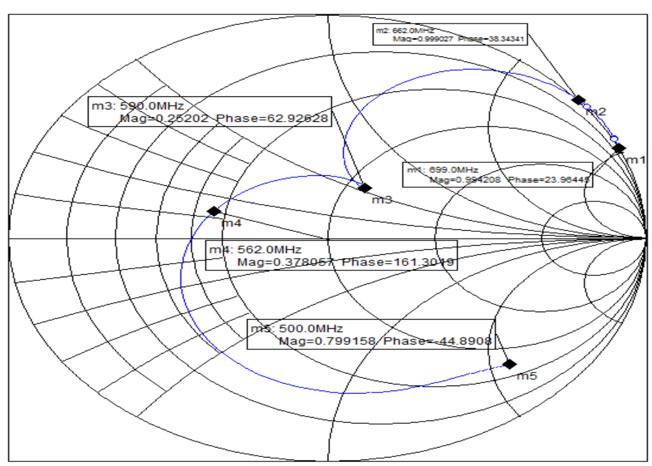

Fig. 10: Smith Chart for Graphene depict the magnitude and phase for the respective frequency.

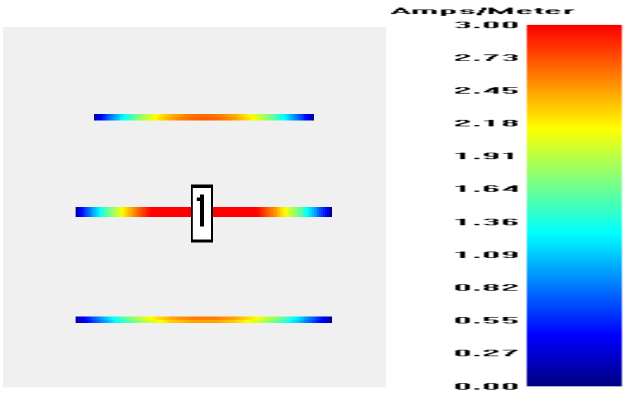

Fig. 11: Current Density distribution in the Yagi- Uda antenna using Graphene as structure material at 590 MHz

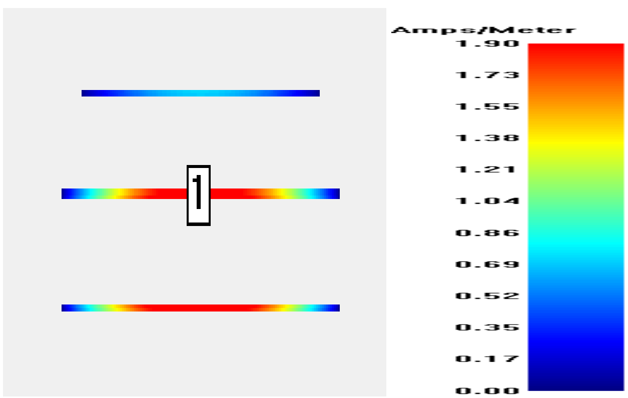

Fig. 12: Current Density distribution in the Yagi- Uda antenna using Graphene as structure material at 580 MHz

The reflection coefficient is measured across a frequency range and plotted on a Smith Chart for Aluminium and Graphene. Fig. ure 10 represents all possible impedances on the domain of existence of the reflection coefficient. As the frequency is increased, the impedance first decreases from 500 MHz to 590 MHz and after that it increases to 600 MHz. This depicts maximum current density to be at 590 MHz because of minimum impedance. Assuming the dipole lies along the z-axis, and assuming the current must go to zero at the ends of the conductor; such a situation will produce the current distribution of:

$$J(z') = (I_o/2\pi a)[\cos(\omega z)] = \mathrm{Re}(I_0/2\pi a e^{-jwt}) \qquad (7)$$

Where the $2\pi a$ factor comes from the fact that the current will be distributed around the surface of the dipole. Fig. 11 and Fig. 12 show the variation of current density on the antenna at 590MHz and 580MHz.

5. RESULTS AND DISCUSSION

Graphene Oxide has been synthesized from Graphite by modified Hummers Method and reduced to Graphene by chemical method. SEM technique is used for characterization of the Graphene sheets which shows ultrathin and homogeneous Graphene films. The simulated results of Graphene based Yagi Uda antenna depicts that it is the highest performance antenna exhibiting more delivered power and increased bandwidth (570 MHz to 602 MHz). The VSWR obtained from our results by using 3 elements in designing Yagi-Uda antenna is in comparison to the values being attained by using Aluminium, Copper and Stainless Steel for 6 and 10 elements respectively [13].

Table 2: Parameters of the Antenna

Reflected Power (dB)	Delivered Power (Ţ)	Mismatch loss (dB)
-12.04	93.75	0.282
Return Loss	Reflection Coefficient (Γ)	Reflected Power (%)
12.00	0.25	6.25

6. CONCLUSION

Graphene a two-dimensional carbon allotrope is a versatile material on the Earth. Its outstanding properties of being the lightest and the strongest material, contrasted with its capacity with behavior heat and electricity better, imply that it can be coordinated into a large number of applications. Simulations data supports the feasibility of the concept of a Graphene -based -antennas. Though numerous difficulties stay open, however this is an initial step towards making Nano machines (NEMS) with possible applications in the biomedical, natural, mechanical and military fields. The Gain of Graphene antennas and the Bandwidth performance is calculated to be the excellent. The reason for overall better performance predicted for Graphene is due to the fact that Graphene has considerably high conductivity. Based on the findings, Graphene is proposed as a potential candidate material for antennas.

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