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Investigating Thermal Conductivity in Graphene Nanocomposites

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Abstract **-** in natural occurrences, two carbon isotopes maintain stability: carbon-12, which accounts for roughly 99% of all naturally found carbon, and carbon-13, constituting approximately 1%. These proportional distributions are also observed in laboratory-produced graphene. Graphene, a single layer composed of sp2-bonded atoms arranged in a hexagonal pattern with a bond length of0.142 nm, exhibits outstanding characteristics such as a high tensile strength of about 130 GPA and exceptional electrical conductivity, holding promise for advancements in battery efficiency. I synthesized graphene using microwave irradiation techniques applied to graphite raw powder. The synthesized of graphene deposited onto two metallic strips measuring 1 mm in dimensions. The incorporation of copper enhances graphene's conductivity and facilitates precise tuning at higher frequencies. The experimental findings presented in this study investigate the adjustable nature of the transmission coefficient (transmitting from port 1 to port 2) within the graphene patch. These findings demonstrate fluctuations of -20 dB at 1.7 GHz, -23 dB at both 2 GHz and 7 GHz, and -24 dB at 8 GHz, achieved through a simultaneous increase in DC bias voltage exceeding the saturation threshold.

Keywords**:** Graphene, DC Bias, Graphite, Thermal and Antenna

1. Introduction

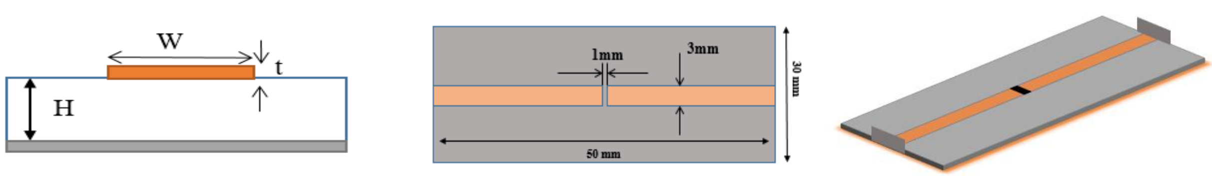
Graphene, as you correctly stated, is a single layer of carbon atoms arranged in a hexagonal lattice. Its discovery in 2004 marked a significant milestone in materials science and nanotechnology [1]. The intriguing electronic properties of graphene have garnered considerable attention in recent years, owing to its extraordinary combination of electrical and mechanical attributes, In the microwave frequency range, graphene demonstrates the ability to modulate its resistance in response to an applied electric field [1,2]. It has tremendous properties like as thermal mobility of hole and electron excess of 100,000 cm^2/Vs at room temperature, exceptional thermal conductivity 5000-5300 W/mK, conductivity of electrical 200,000 cm^2/Vs and 400,000 cm^2/Vs respectively of electron and hole mobility at perception of room temperature and mechanical strength, tensile 130 GPa and young modulus ~1 TPa [1,3].

Graphene electron it become a role of zero-bandgap material called Dirac point reason for conduction and valance bond direct connected to each other [4,5,6]. In some previous years, have more expectation in terahertz science and technology, wide band of research areas such a long distance communication, wireless, medical devices, weather predictions and geological sciences etc. Specially, antenna design, the focus in low loss of signal and study predominately lies within the mm wave category of frequency spectra [7]. An antenna, used received and transmit a EM waves, which are crucial components for wireless systems attracting approach in the transmission like microstrip patch antenna because of light weight, low cost, easily fabricate etc. In the 1970s, pioneering efforts were made in the field of terahertz (THz) microwave research, aiming to elucidate the coverage of diode detectors across the spectral frequency range. [1,2,8]. A microstrip patch antennas are characterized by low profile design application at few MHz up to 100 GHz. The geometry, a metal patch (conductive layer such as copper and gold) attached via a ground (fringing effect) with dielectric level of substrate layer, phenomenon microstrip design. Metal patch various shapes features: square, ring, ellipse etc. [1,4,8,9]. Graphene have major research applications among physicists and engineers, who acknowledge improving a range of technologies, such as digital and RF electronics, low-power switches, sensors and energy charger systems etc. This objective of this paper to enhance EM wave and progress for RF devices to employing graphene [10, 11].

In this study, we conducted the design of a microstrip patch operating at 10 GHz. The design has achieved high gain, compact size, slim structure, lightweight and low power consumption by Ansys HFSS tool used. Computerized simulation defined, s11 reflection coefficients (dB vs Hz), radiation pattern operates at E-plane at the operating frequency. The microstrip antenna, proved with experimental and computational designed and works successfully. I designed graphene nanoplatelets (GNPs) definition of wide area of sheets but a single atom layer. GNPs designed chemical synthesis process and thermal analysis from microwave irradiation process. GNPs is isotopes of carbon as similar as graphene, difficult to design fabrication process and suddenly change property in the presence of ambient temperature reason of OH and H functional group. I obtained expandable graphite through the process of thermal expansion. Furthermore, incorporating GNPs into an electrical circuit can be accomplished through a bottom-up self-assembly approach and implementing attenuators or tunable antennas.

2. Tunable of Graphene Patch

We design a microstrip patch antenna using the graphene, characterized by a miniaturized size and couple of align patch design defined of s-parameter by vector network analyzer. In order to design a wide band antenna features for high frequency reconfiguration with a metal patch, which resonate by coupling effect on a graphene pad. Here, it seems to be substrate FR4 (flame retarded), relative permittivity of the substrate ε = 4.4 with a thickness t = 1.6 mm. In this study Graphene created by chemically, doped in between 1 mm space copper metallic surface via a ground patch design microstrip antenna to enhance wider wavelength for high frequency applications operating at 10 GHz. Tuned graphene when increase DC bias voltage through bias tee reason for VNA carry only RF signal.



(a) (b) (c)

Fig. 1 Basic structure of microstrip patch antenna design: (a) side view, (b) top view (c) substrate design by ANSYS HFSS*

In the Table 1. Perform various parameters describe for microstrip antenna. In Fig. 1 microstrip, patch antenna upper layer copper (a), the overall dimensions 50 X 30 X 1.6 mm^3 (b) and computational design FR4 substrate by Ansys software (c). FR4 substrate defined for two side copper plate formation. It has designed for low cost and easy fabrication for high frequency application like aerospace, microwave coaxial, and transmission line etc. The graphene pad, when coated on a metal plate strip, biased, and aligned properly, functions as a resistor, while the dielectric substrate serves to store electric energy.

Table 1. PARAMETER OF THE PROPOSED ANTENNA

Parameters	Value
Frequency	10 GHz
Substrate thickness (t)	0.035 mm
Graphene thickness	~0.01-0.05 mms
H	1.54 mm
L	50 mm
Feedline thickness	3 mm
W	30 mm

2.1 Graphene Conductivity

The surface conductivity defined depends on two parameters: intra-band (transition within same energy bands) and inter inter band (occurring different energy bands) used. There is no significant effect in the intra-band frequency in THz band. band.

The surface conductivity is

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

The band $\sigma_{intra}(\omega)$ is a combination of real and imaginary values expressed

$$\sigma = \sigma_r + j\sigma_i \quad (2)$$

At low frequencies, Intraband transitions predominantly govern the conductivity of graphene, with longer wavelength photons possessing insufficient energy to facilitate Interband transitions, thereby prompting Intraband transitions instead [12]. Drude dispersion formula:

$$\sigma(\omega) = \frac{\sigma DC}{1 + j\omega\tau} \quad (3)$$

The electrical conductivity of direct current and electron momentum relation time is σ_{DC} and τ respectively nature.

3. Chemical Composition

Basic, experimental setup direct sonication mix with water includes formic acid for 3 min up to 30 min after heat suspension from microwave irradiation (duration ~5 min) dependence on the crystalline structure to the surface analysis and surface analogy w.r.t. intercalated bond energy between the carbon layer. An ultra-sonication frequency ranges around 37-45 KHz and power 70-140 W using a vibration technique operating at normal ambient (20-60℃) temperature [12].

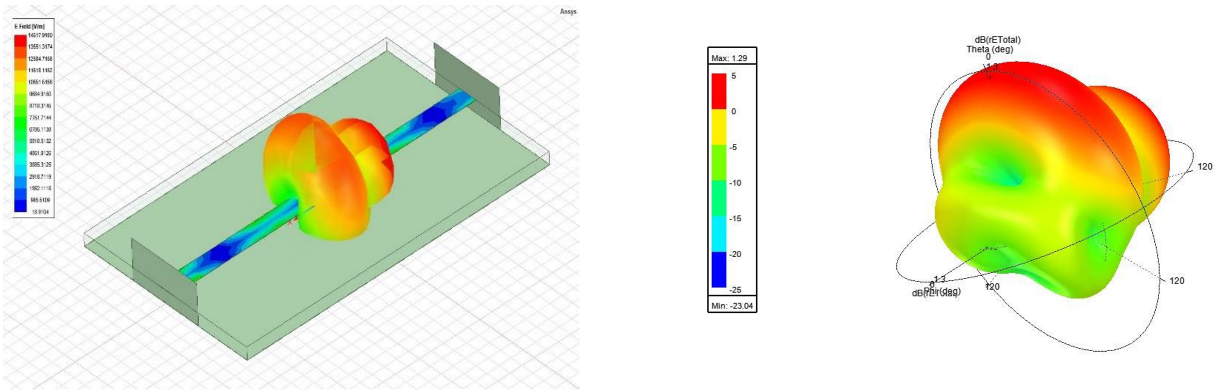
3.1 Role of hydrogen bond: Formic acid is a part of OH and the hydrogen bond is an organic molecule compound the existence of various bonded structures is defined as a particular reason for the interaction of water compound[13]. HCOOH (hydrogen density of 53 g/litre) bond structure organic molecule and familiar water interaction soluble aqueous solutions in an environment which is independent and soluble in water but hydrocarbon partially miscible even many polar solvents which have *namely red ant* or *Formica rufa* discovered 1670, found two counterpart orientation with bonded structures[14]:

$$HCOOH + water \rightarrow HCOO^{-} \text{ (conjugate acid)} + H_3O^{+} \text{ (functional group)} \quad (4)$$

In the bath sonication process, a range of 30-60 min with mechanical stirring for particular a low acid concentration with aqueous solutions[14], [15] was prepared expends with ultrapure water and reaction filled with 50 ml solution in a volumetric flask [16].

4. Result and Discussion

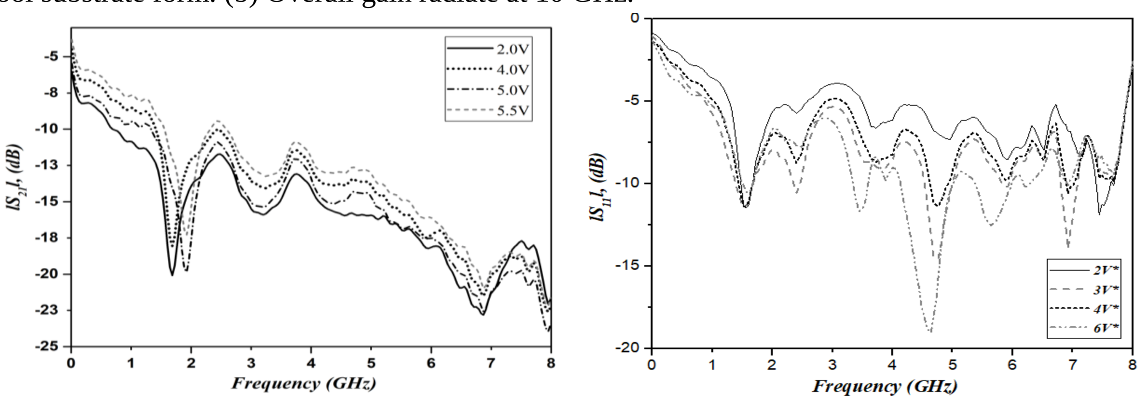
We conducted a simulation of the antenna by utilizing graphene combined with a metal strip, which emits energy upon the activation of the increased Mag-E field mechanism in the operating GHz. Figure 2 shows the radiated when radiation pattern presented in the paper according the voltage and frequency range.



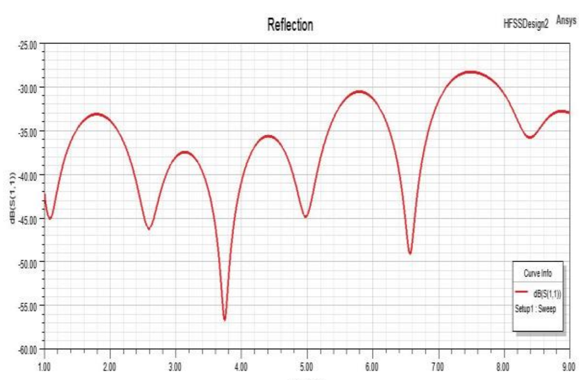
(a) (b)

Fig. 2 shows rediation spectrum on metal strip antenna design

In the figure 2. (a) Radiating pattern explore because of graphene presented in between two metal space antenna. Graphene is works as a highly conducting and super condcuting material depends on carbon layers in micro and nano range thickness. Two port rectangle port top and bottom works as a excitation port which is patch attached with metal strip. Here, it is electric field flowed from top to bottom layer reason for fringing effect. When graphene heat than radiate it to front side then make a major lobe and back side lobe creat known as minor lobe which is make a good example to cool substrate form. (b) Overall gain radiate at 10 GHz.



(a) (b)



(c)

Fig. 3 Shows scattering coefficients varies at different power supply

In shown figure 3. (a) Transmission coefficients experimental value changed for conducting behaviour when increased increased DC bias voltage at certain temperature. The reason for Graphene functioning as a resistor lies in the alteration of of voltage and current. The transmission scattering parameter has two major frequency resonance at 1.5 GHz and 2 GHz and and other some minimum frequency resonates at 3 GHz and 7 GHz constantly curve facing at voltage change that mean absorbance reflectance to the metal plate substrate. Fig. 3, (b) shows reflection experimental analysis that graphene is changed at frequency ranges. At 4.5 GHz signal less signal reflect mean that frequency resonance at 1.3 GHz, 2.5 GHz, 3.5 GHz various dramatically change at various dc voltages power, (c) computational design approach define reflection power has maximum value at 4.5 GHz and 6.5 GHz respectively. The thermal expansion of graphene exhibits distinctive characteristics that are crucial for precise tuning and alignment.

5. Chemical analysis

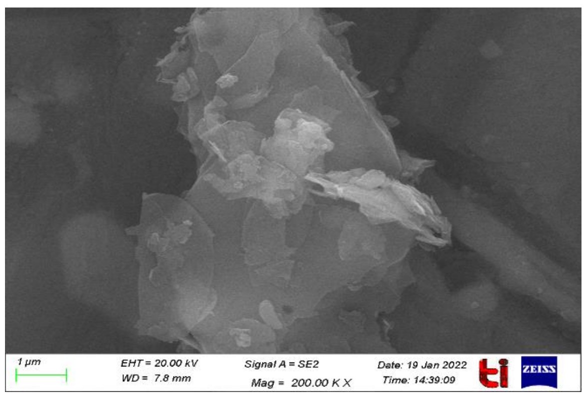


Figure 5. Single layer of Graphene film shown

In Figure 5, carbon layers are depicted as stacked in a single layer 1µm, exhibiting remarkably strong bonds that facilitate favourable interactions with other bonding forms. A single layer of carbon forms strong bonds between carbon atoms, enhancing thermal conductivity and enabling sustained sensitivity to high temperatures. The thermal reduction of graphene by the oxidation from graphite overcome minerals like oxide, and OH group etc. Increasing the DC power supply and patch heat radiation are stimulated due to the presence of carboxyl groups, enhancing thermal efficiency. Graphene has produced by chemical composition technique used catalyst and other reagent through microwave irradiation techniques. This technique leads to a minimal production of single-layer sheets and an abundance of multi-layered structures composed of platelets.

Table 2. Chemical elemental Mapping post synthesis

Element	At. No.	Mass Norm. (%)	Atom (%)	Abs. error (%)	Rel. error (%)
C	6	70.67	79.01	3.51	4.97
O	8	22.77	19.11	1.23	5.40
S	16	3.02	1.27	0.10	3.22
K	19	0.84	0.29	0.03	3.37
Mn	25	0.84	0.21	0.04	4.66
Au	79	1.85	0.13	0.14	7.77

In the Table 2. Chemical elemental analysis after synthesis process where is origin of carbon sample present at high percentage as comparison to other element. Au and K, at low purity level in acidic solutions. Mn and S are generating through the oxidation reaction when mixed HCL and H_2SO_4chemical in graphite raw powder or at ambient temperature.

6. Conclusion

In this paper, a metal strip patch antenna reconfigures of graphene intended for increased bandwidth and wireless communication which is good result for reflection and transmission at more than 6 GHz. Computational design of graphene is partial radiated at metal strip film as same as experimental result. I achieved 10 GHz frequency range and highly reactive reaction at over 6 GHz.

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