REDUCTION OF REFLECTORS BY USING GRAPHENE AS AN ANTENNA

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• ABSTRACT:

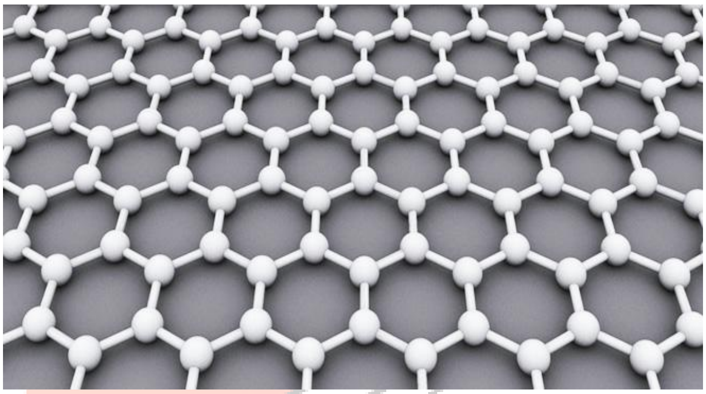
Now a days we are using large reflectors to focus the signal in a particular direction by implementing graphene as an antenna. We can eliminate the reflective as the size of graphene and increases the radiation pattern will be increased by implementing graphene in an antenna and also we can eliminate more number of base stations in a particular geographical area and receive even more number of signals and can send more number of signals from the antenna.

• KEY WORDS:

Reflectors-graphene-radiation-implementation-antenna–stations-geographical.

• INTRODUCTION:

It is observed that the graphene technology has attracted growing interests and its potential applications for various fields have been discovered in the last decade. The gapless energy spectrum in graphene makes it an attractive candidate for massive nano electronics and Nano photonics devices such as terahertz antennas, filters, oscillators, plasmonic Bragg reflectors, absorbers, and surface acoustic-wave amplifiers. Since the surface complex conductivity of graphene can be dynamically controlled by changing the applied voltage, it opens up unprecedented opportunities in developing reconfigurable plasmonic devices at terahertz and mid-infrared frequencies.



• I. Basic yagi-uda based graphene antenna:

The Yagi-Uda antenna is a typical end-fire antenna composed of the radiation and parasitic elements, which has been widely adopted for TV signal reception. It is fed by only a single feeding port, and the parasitic-element is excited by means of electromagnetic coupling of the dipole antenna. Besides the simple structure, Yagi-Uda antennas have the potential to be designed as pattern reconfigurable antennas covering the full azimuth plane. The classical reconfigurable Yagi-Uda antennas are designed by switching the state of PIN diodes inserted on parasitic elements, forcing them to act as directors or reflectors and thus changing the main beam direction. However, the conventional electronic based control switches are not available in the terahertz frequency range due to the limited frequency performance. Fortunately, graphene can be introduced as the “switch” for terahertz-frequency devices because of its active complex conductivity. Some antennas take advantage of the graphene by making the frequency or the radiation pattern reconfigurable such as the MIMO antennas, leakywave antennas, Yagi antennas, micro strip quasi-Yagi antennas, reflect-array antennas, slot antennas, and dipole antennas. This have reconfigurable dynamic radiation patterns, but the beam adjustable range is limited. In this paper, a type of graphene-based reconfigurable Yagi-Uda antenna with two or four radiation patterns is proposed, where the radiation patterns can cover the full azimuth plane. The direction of main radiation beam is controlled by different chemical potentials applied on the parasitic stubs' graphene. We show that the variable chemical potential could affect the front-to-back ratio and the resonance frequency of the proposed antenna. Furthermore, we outline that the proposed reconfigurable antenna is valid for graphene-based Yagi-Uda antenna with more radiation patterns (i.e., 6-, 8- patterns and so on). Such antennas with high directionality (i.e., high gain) could be ideal for a number of applications including wireless sensor networks and the last mile access network employing hybrid free space optics and radio frequency technologies, which offer improved link performance. Due to the advancement of the planar implementations, the graphene-metal hybrid implementation in Refs has become available. In particular, this technology has been demonstrated experimentally. The rest of the paper is organized as follow. The following sections describe the antenna configuration and radiation mechanism based on the graphene. Section II provides a two-beam pattern reconfigurable Yagi-Uda antenna. Section III proposes a Yagi-Uda antenna with four reconfigurable antenna. Section III proposes a Yagi-Uda antenna with four reconfigurable beams by extending the design method outlined in Section II. Finally, the concluding remarks are presented in Section IV.

- ## II. THE DESIGN OF A TWO-BEAM RECONFIGURABLE YAGI-UDA ANTENNA

The reconfigurable terahertz graphene-based Yagi-Uda antenna with two-beam patterns is simulated using the Full-Wave Electromagnetic Simulator. Graphene with a single atom thickness can be modelled as a 2-D surface with complex conductivity σ. The conductivity is composed of two elements: the inter-band and intra-band.

Figure 2 presents the layout schematic of the two-beam reconfigurable Yagi-Uda antenna with the geometrical parameters. It consists of a driven dipole radiation conductor (fed by a 50 Ω source) and two parasitic elements. Both parasitic elements are integrated with graphene

The graphene strips implanted in the dipole antenna are used for connecting the two radiation arms, with the applied chemical potential μc1 of 0.4 eV. If the chemical potential μc2 is set to 0.4 eV and μc3 is set to 0 eV, the corresponding parasitic elements A and B in Figure 1 behave as a director and a reflector for the–Y direction 1 (D1), respectively. Similarly, when the chemical potential μc2 is set to 0 eV and μc3 is set to 0.4 eV, the corresponding parasitic elements A and B in Fig 2 perform as a reflector and a director for the +Y direction 2 (D2), respectively.

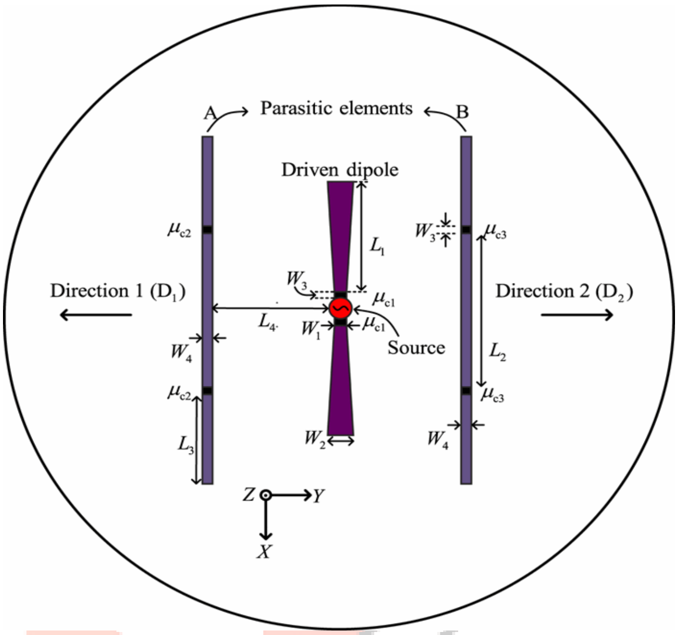


Fig 2: Two beam reconfigurable yagi-uda antenna as driving element as graphene.

This is because the conductivity could be alternated by integrating graphene strips. Based on this property a reconfigurable two-beam Yagi-Uda antenna is proposed. All the accurate values of geometrical parameters are listed in TABLE I. Figure 2 shows the current distributions for the proposed antenna for D1 and D2 with identical excitation signals. In Figure 2(a) with the chemical potentials μc2 of 0.4 eV and μc3 of 0 eV, the left (A) and right (B) parasitic strips acts as a director and a reflector, respectively. Since the left parasitic strip (A) is inductive, the phase of the current in parasitic element lags the dipole radiation element's current. 35 the current distribution changes when the μc2 and μc3 are set to 0 eV and 0.4 eV, respectively.

In this case, the right (B) and left (A) parasitic strips act as a director and a reflector, respectively as shown in Figure 2(b). Because of the graphene with a complex conductivity, the conductivity of the parasitic elements can be altered by simply controlling the chemical potentials μc2 and μc3. Figures 3(a) and 3(b) illustrate the simulated radiation patterns of the proposed two-beam reconfigurable Yagi-Uda antenna at 3.73 THz for both D1 and D2 in the XOY and YOZ Planes.

Excellent unidirectional symmetrical radiation patterns with the 11.9 dB front-to-back ratio have been achieved by simply alerting the chemical potentials µc2 and µc3.

The achievable gain of this proposed antenna is about 7.8 db. The simulated reflection coefficients |S11| for both D1 and D2, for this proposed antenna. Note that the reflection coefficients are highly stable in both two radiation directions D1 and D2. It can be observed that this antenna is resonating at 3.73THz and the 10-dB impedance bandwidth is about 15%. As can be seen from Figures 5 and 6, the chemical potential µc3 for D2 does affect the front-to-back ratio and the resonating frequency position of the proposed antenna, simultaneously. Figure 3 show the simulated radiation patterns (XOY and YOZ planes) of the proposed antenna for D2 (µc1 = 0.4 eV and µc2 = 0 eV) with the chemical potential µc3 of 0.4 eV, 0.6 eV, and 0.8 eV applied to the right (B) parasitic strips at 3.73 THz. The right (B) graphene-based director guides the radiation toward the +Y direction. The front-to-back ratios are radically changed from 11.9 dB to 6.7 dB when the chemical potential µc3 varies from 0.4 eV to 0.8 eV. The reflection-coefficient results show that the chemical potential µc3 can affect impedance-matching performance. In order to further clarify the values of chemical potentials for two directions (D1 and D2). The effect of relaxation time τ on the performance of the proposed two-beam reconfigurable Yagi-Uda antenna is discussed here.

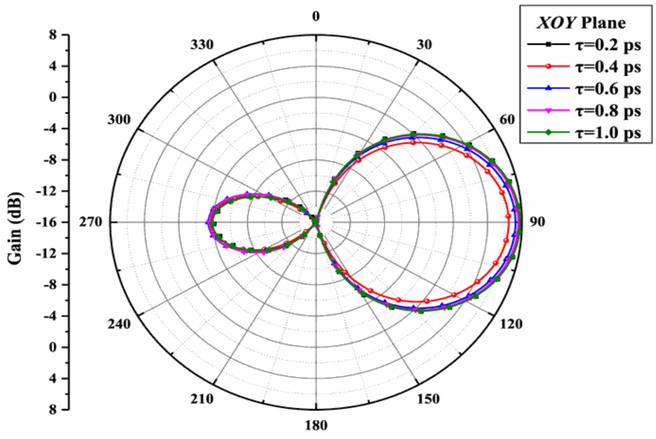


Fig 3(a): Gain of antenna in XOY plane.

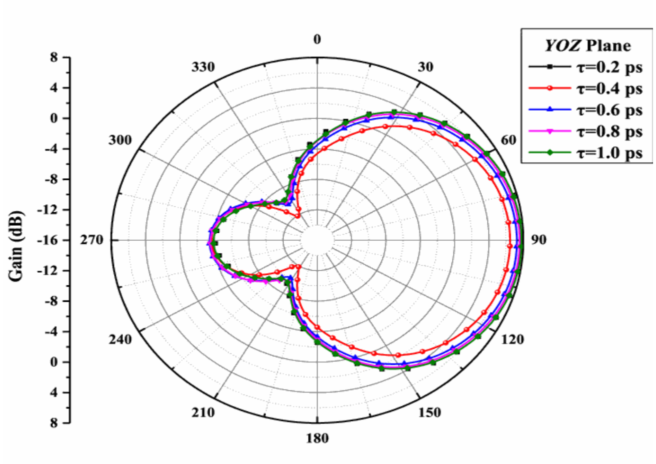


Fig 3(b): Gain of antenna in YOZ plane.

III. THE DESIGN OF THE FOUR-BEAM RECONFIGURABLE YAGI-UDA ANTENNA:

The layout structure and three-dimensional view of the four-beam reconfigurable Yagi-Uda antenna are shown in Fig 4. It consists of two orthogonal driven dipoles, four parasitic strips, and four parasitic rectangular loops. The values of chemical potentials µc5 and µc6 surrounding two dipoles determine which one will work.

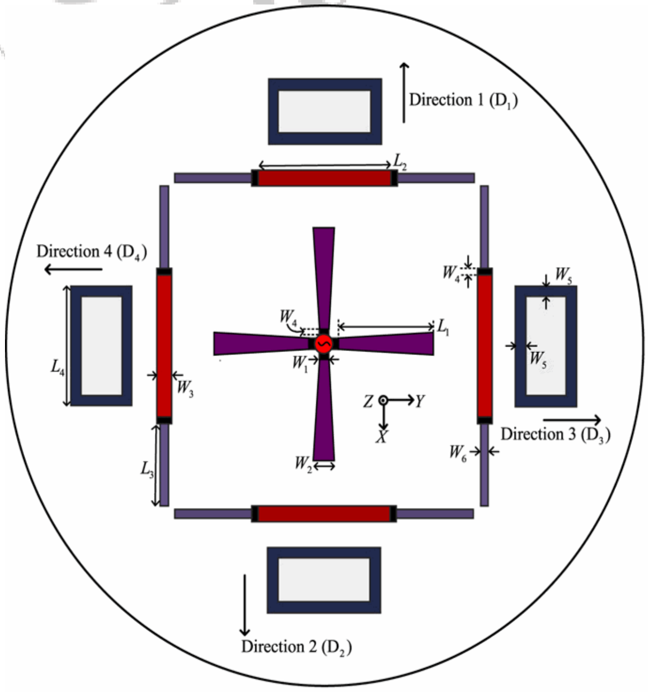


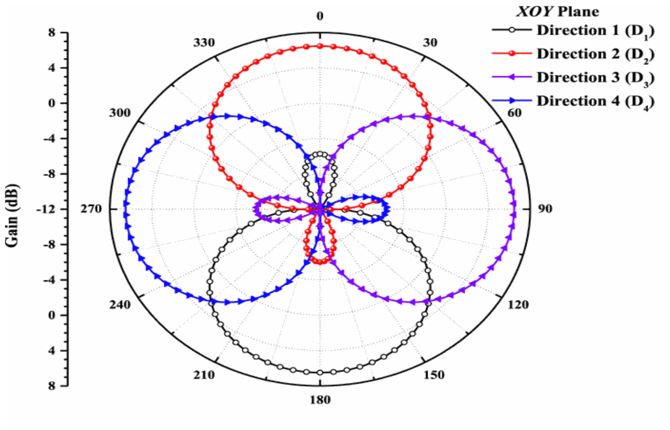
Fig 4: four beam reconfigured antenna.

The effect of the electron relaxation time τ on scattering parameters and radiation patterns at XOY Plane and YOZ Plane of the two-beam reconfigurable Yagi-Uda antenna for D2: (a) The curves of $|S_{11}|$ with variable electron relaxation time τ when the chemical potentials μ_{c1} and μ_{c2} are set to 0.4 eV and μ_{c3} is 0 eV, and simulated radiation patterns of XOY Plane (b) and YOZ Plane (c) at 3.73 THz when the electron relaxation time τ changes from 0.2 ps to 1.0 ps.

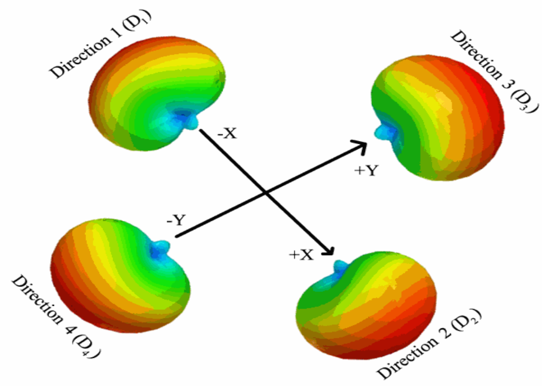
Configuration of the four-beam reconfigurable Yagi-Uda antenna and parameter definitions: (a) top view, and (b) three-dimensional view. Graphene stubs in four parasitic strips will determine whether the parasitic strips act as directors or reflectors. After careful simulation, a typical example for four-beam reconfigurable Yagi-Uda antennas is obtained. The five cross profiles and one three-dimensional radiation patterns of this proposed four-beam reconfigurable Yagi-Uda antenna at 1.88 THz are plotted. It is very obvious and clear that four radiation patterns with different beams but similar shapes can be achieved in this proposed Yagi-Uda antenna. The parasitic strips, with two special chemical potentials of 3 eV and 0 eV, are capacitive and inductive and will act reflectors and directors, respectively. When the Y-direction driven dipole is conductible (μ_{c5} = 3 eV and μ_{c6} = 0 eV), and the +X direction's chemical potential of the graphene in the parasitic strip μ_{c1} = 3 eV (μ_{c2} = 0 eV, μ_{c3} = 0 eV, and μ_{c4} = 0 eV), the proposed antenna has an end-fire radiation pattern in the–X direction (D1).

Similarly, when the chemical potential of the graphene in the -X direction μ_{c2} = 3 eV (μ_{c1} = 0 eV, μ_{c3} = 0 eV, and μ_{c4} = 0 eV), the proposed antenna has an end-fire radiation pattern in the +X direction (D2). Based on the same operation, the proposed antenna can possess other two different beam patterns in +Y and -Y directions, namely, D3 and D4. The simulated results show that the peak gain of the proposed four-beam reconfigurable Yagi-Uda antenna is about 6.4 dB and its front-to-back ratio is about 12 dB. In addition, Figure 10 shows that the proposed antenna has stable reflection-coefficient performance although four main beams in reconfigurable cases point to four totally different directions, and the 10-dB impedance bandwidth is about 10 %. In order to further clarify the values of six chemical potentials for four directions (D1, D2, D3, and D4).

Simulated radiation patterns of the proposed Yagi-Uda antenna with four reconfigurable beams at 1.88 THz: (a) XOY Plane and (b) three-dimensional radiation patterns for D1, D2, D3, and D4.



(a)XOY Plane



(b)Three-dimensional radiation patterns for D1, D2, D3, and D4.

Different from the previous two-beam reconfigurable Yagi-Uda antenna, four parasitic rectangular loops have been added in this four-beam reconfigurable Yagi-Uda antenna.

Therefore, four parasitic rectangular loops behave as directors for enhancing the directivity of the proposed four-beam reconfigurable Yagi-Uda antenna. Similarly, the rectangular loops would also improve the front-to-back radio for the two-beam pattern reconfigurable Yagi-Uda antenna.

IV. CONCLUSION

A kind of Yagi-Uda antenna based on graphene with radiation pattern reconfigurable function has been proposed in this article. The dynamic conductivity of the graphene, implanted in driven dipole antenna and parasitic elements, which can be tuned by changing the chemical potential, allows the proposed antennas to change the radiation beam into two or four different directions.

Due to the complex conductivity of the graphene, the parasitic strips can act as directors (reflectors) when they are inductive (capacitive). The function of the parasitic strips can be easily altered between directors and reflectors by simply changing the chemical potentials applied to the graphene. Excellent unidirectional symmetrical radiation patterns with the front-to-back ratio of 11.9 dB achieved by choosing the suitable chemical potentials for the proposed two-beam reconfigurable Yagi-Uda antenna.

The peak gain is about 7.8 dB and the 10-dB impedance bandwidth is about 15%. In the proposed four-beam reconfigurable Yagi-Uda antenna, the simulated results show that it has stable reflection-coefficient performance although four main beams in reconfigurable cases point to four totally different directions.

The corresponding peak gain, front-to-back ratio, and 10-dB impedance bandwidth are about 6.4 dB, 12 dB, and 10%, respectively. It can be expected that this proposed design idea in this article possesses high potential for beam scanning in terahertz and mid-infrared plasmonic devices and systems, owing to the reconfiguration capabilities of the graphene and the end-fire characteristics of the Yagi-Uda antennas.

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