International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Simulation and Performing of Conical Nano DRA for Device to Device Communication

Amit Ranjan Sahu[1], Anand Chaurasia[2], Arun Kumar Gupta[3]

[1]Electronics and Communication Department, Galgotia College of Engineering and Technology
amitran4812[at]gmail.com

[2]Electronics and Communication Department, Galgotia College of Engineering and Technology, Greater Noida, India
anandchourasia431[at]gmail.com

[3]Electronics and Communication Department, Galgotia College of Engineering and Technology, Greater Noida, India
arun9670008001[at]gmail.com

Abstract: ***In this article a nono dielectric resonator antenna (DRA) is implemented for the THz frequencies. In the DRA all dimensions are in the nanometer range to operate for THz applications. Proposed geometrical (conical) dielectric resonator (DR) has high efficiency, low loss and compact size. The following work is to design antenna high gain gain of dBi and radiation efficiency of 82.47% at the frequency of 4.86 THz.***

Keywords: conical, dielectric resonator, antenna, THz, DRA

1. Introduction

In recent years wireless communication is being developed considering the THz band applications [1]. As the size of chips is shrinking drastically, it's the modern requirement to design a nano-sized antenna that suitable for modern devices and works on the THz frequencies, which provides a large bandwidth to work. So to fulfill the modern requirements we have come to a solution for the THz antenna. A THz antenna can be categorized into three ways (i) antenna with metal/dielectric radiator (ii)antenna with the radiator of 2D material (iii) with the interface of metal/dielectric/graphene. In the first case, the metallic radiator antenna, the surface wave, and conductor losses are high at THz frequency, hence they become less efficient [2-8]. The antenna implemented using dielectric material as a radiator always remains in the advantage of providing high gain and high efficiency [7].

In recent decades the dielectric resonator antennas have been comprehensively studied and major area of research because of their appealing characteristics such as high radiation efficiency and gain, wide bandwidth, low surface wave, and conduction losses, and reduced power consumption in comparison to metallic antennas [9]. The DRA can also be implemented for frequency range 0.1 THz-10 THz with very low losses. DRA has been prominent for the last three decades in the microwave frequency range due to providing high gain, high efficiency, and wide bandwidth [4]. In the dielectric resonator antenna (DRA) as the name suggest a dielectric material is used for designing the antenna. A high permittivity antenna dielectric material reduces the size of the antenna and also provides enhanced performance [5]. The Dra is implemented for THz region frequency by utilizing the silicon made DR. The utilization of silicon material provides high permittivity which can enhance the radiation properties like gain and radiation efficiency [6].

So learning from above, the proposed geometrical antenna design which is a conical dielectric resonator (DRA) can be implemented in chip level devices for the device to device communication in nano networks in the THz frequency range.

2. Antenna Design

We proposed a conical shape DRA antenna for THz frequency. In this prototype, we use the substrate material of silicon dioxide (=4, =1, and mass density=2220) having dimensions (42*42*6) nm. And the ground plane made up of silver (=1, =0.9999) and mass density=10500), and dimensions are (42*42*6) nm. Nano wave-guide material Silver (=1, =0.99998 and mass density=10500).NANO wave guide length=21nm and width=3nm. At the top of the ground plane, we put a conical shape DR. We use Silicon (=11.9, =1, loss tangent= 0.001 and mass density=2330) and the radius of base touching to the ground is 4nm, and the radius of the top of the cone is 3nm.

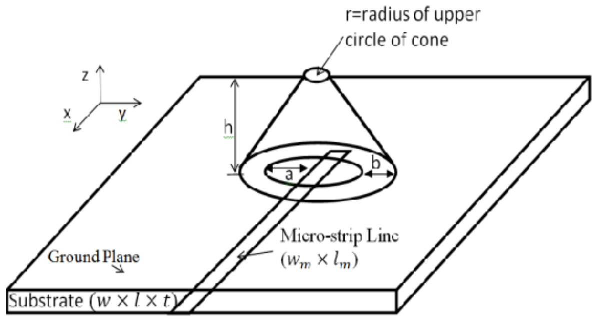


Figure 1: Conical shape dielectric resonator antenna

Component	Material	Length	Breadth	height
Ground plane	Silver (ε_r=1, μ_r =0.99998 and mass density=10500)	42	42	8
Substrate	Silicon dioxide (ε_r=4, μ_r=1 and mass densiy=2220)	42	42	8
Antenna (conical)	Silicon (ε_r=11.9, μ_r =1, loss tangent= 0.001 and mass density=2330)	4 (radius)	-	3

Feed line	Silver (ε_r=1, μ_r =0.99998 and mass density=10500)	21	3	

All the dimensions are in the nanometer range to perform the antenna inthe THz frequency range.

3. Stimulation and Performance

To understand the results of the proposed conical DRA antenna we have designed an antenna and stimulated it. It is a simple DR antenna whose dimensions are discussed in the antenna design. The operating frequency of the designed antenna is 4.826 THz and all the dimensions are in the nm range. The conical shape is preferred for the ultra-wide bandwidth over other structural DRA and it is found using the mathematical calculations. To understand the antenna structure is implemented and analyzed. Fig(2) presents the basic structure of the antenna in which the bottom-most part is the ground plane and the shape of the antenna is conical and the feeding method is a microstrip patch where the port is performed.

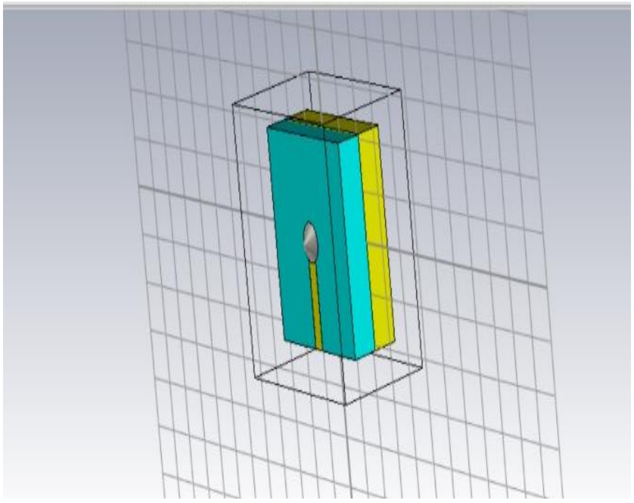


Figure 2: Design of the antenna

The conical DRA is used for the ultra-wideband frequencies in the devices. Since DRA has high bandwidth gain and efficiency at higher frequencies over microstrip patch antenna is the most preferred design for the high frequencies. Fig (3) shows the 3D pattern of the farfield i.e. how the antenna is performing.

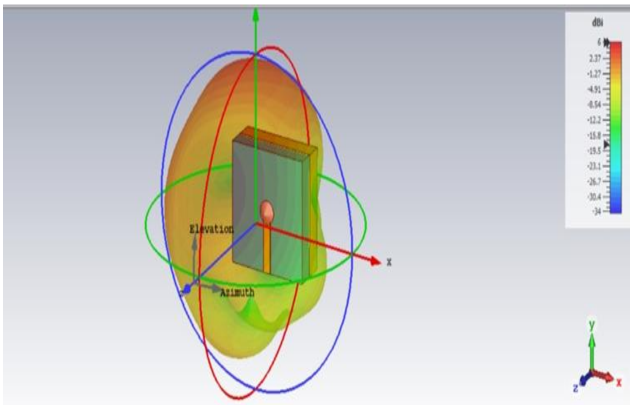


Figure 3: 3D pattern of farfield of proposed conical DRA

The operating frequency of the proposed antenna is 3THz to 5THz. The radiation loss is minimum at 4.826THz and gain at this particular frequency is 6.001dB.

Fig (4) represents the s parameter of the antenna obtained after stimulation of antenna.s parameter describes the input output relationship and also known as the return loss. It represents the reflected power from the antenna.

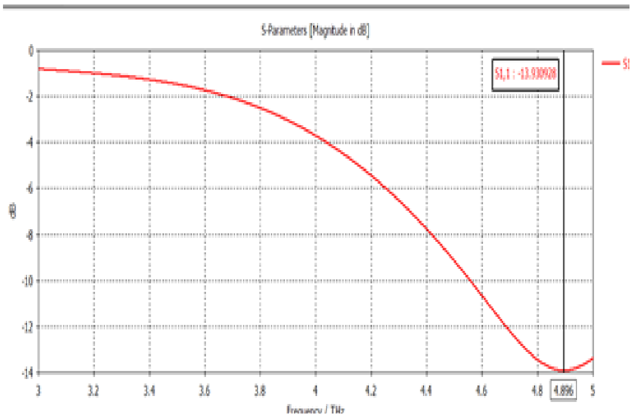


Figure 4: S11 parameter

The S11 parameter is minimum at the 4.826THz so at this frequency the return loss is minimum so at this particular frequency we will get the maximum gain and efficiency.

Fig (5) shows the gain vs frequency graph of the antenna between 4THz -5THz. At the particular frequency (at 4.826 THz) the gain achieved is 6.001dB.

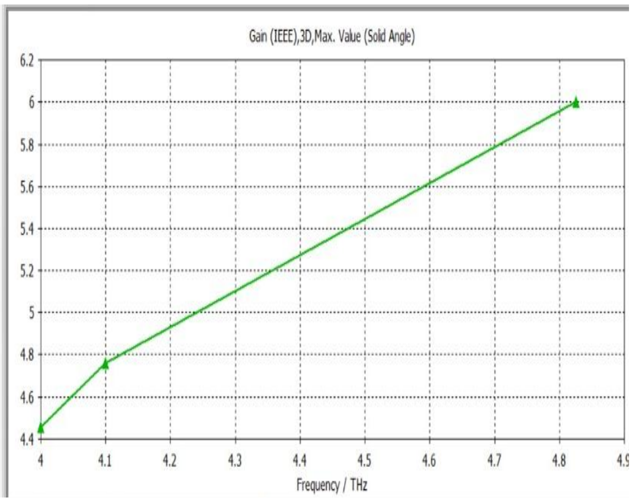


Figure 5: Gain vs Frequency

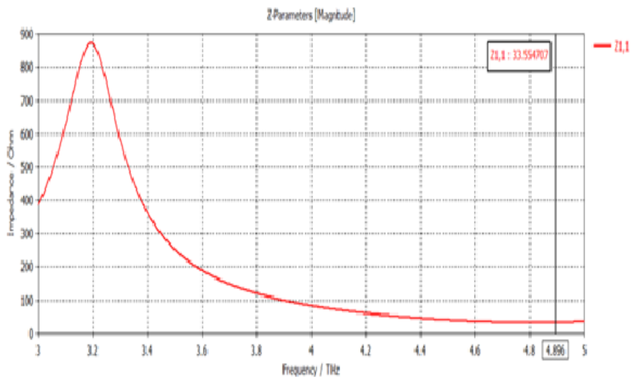


Figure 6: Impendence vs Frequency

Fig (6) shows the graph between the impendence and frequency at hte resonant frequency the impedence of the antenna is 33.55ohm.

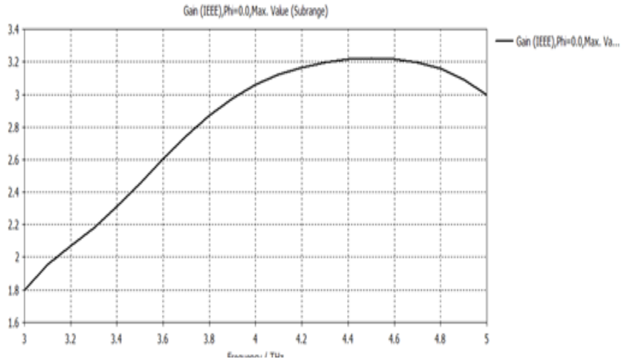


Figure 7: Gain (dB) vs Frequency(THz)

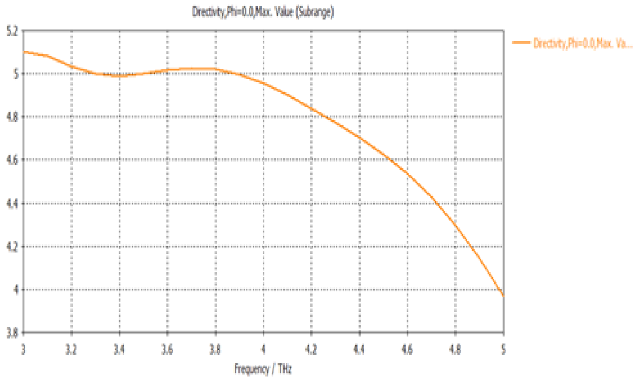


Figure 8: Directivity vs Frequency

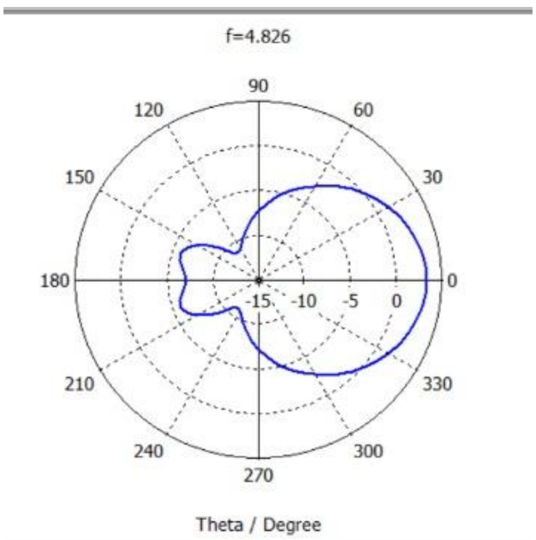
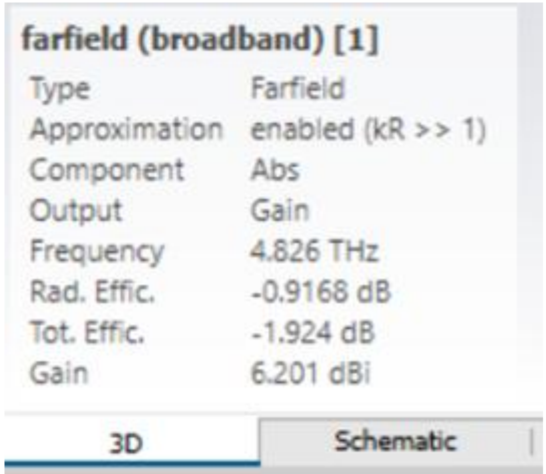


Figure 9: Gain Graph at 4.826THz Frequency

After the stimulation of the deigned DR antenna we achieved the following results:



The results obtained by the stimulation is
gain: 6.201 dBi
Radiation efficiency: -0.9168dB
Total efficiency: -1.924dB
So on calclating the radiation efficiency using the mathematical function :
Gain = efficiency *directivity
So efficiency is
Efficiency= (gain/directivity)*100
So on calculating the efficiency percentage it is 84.17%.

Gain	Efficiency
6.201dBi	84.17%

4. Result and Analysis

After the stimulation of the designed conical dilelectric resonator antenna (DRA) we hav achieve the efficiency of 84.17% and gain of 6.201dBi.this antenna can be used for the device to device communication at THz frequency range. The described antenna design is used for the ultra-wideband frequencies.

References

[1] F. Akyildiz, J. M. Jornet, and C. Han, "Terahertz band: Next frontier for wireless communications," *Phys. Commun.*, vol. 12, pp. 16–32, 2014, doi: 10.1016/j.phycom.2014.01.006

[2] G. Varshney, S. Gotra, J. Kaur, V. S. Pandey, and R. S. Yaduvanshi, "Obtaining the Circular Polarization in a Nano-Dielectric Resonator Antenna for Photonics Applications," *Semicond. Sci. Technol.*, vol. 34, no. 7, p. 07LT01, 2019, doi: 10.1088/1361-6641/ab1fd1.

[3] G. Varshney, "Ultra-Wideband Antenna Using Graphite Disk Resonator for THz," *Superlattices Microstruct.*, 2020, doi: 10.1016/j.spmi.2020.106480.

[4] S. Singhal, "Ultrawideband elliptical microstrip antenna for terahertz applications," *Microw. Opt. Technol. Lett.*, vol. 61, no. 10, pp. 2366–2373, 2019, doi: 10.1002/mop.31910.

[5] S. Singhal, "Elliptical ring terahertz fractal antenna," *Optik (Stuttg).*, vol. 194, no. May, p. 163129, 2019, doi: 10.1016/j.ijleo.2019.163129.

[6] *Sharma and G. Singh, "Rectangular microstirp patch antenna design at THz frequency for short distance wireless communication systems," J. Infrared, Millimeter, Terahertz Waves, vol. 30, no. 1, pp. 1–7, 2009, doi: 10.1007/s10762-008-9416-z.*

[7] R. A. Sadeghzadeh and F. B. Zarrabi, "Metamaterial Fabry-Perot cavity implementation for gain and bandwidth enhancement of THz dipole antenna," *Optik (Stuttg).*, vol. 127, no. 13, pp. 5181–5185, 2016, doi: 10.1016/j.ijleo.2016.02.072.

[8] S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[9] Antar, Y. M. M. and Z. Fan, "Theoretical investigation of aperture- coupled rectangular dielectic resonator antenna," *IEE Proc. — Microwaves, Antennas Propag.*, Vol. 143, No. 2, 113, 1996.

[10] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[11] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[12] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.