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Design & Study Of Carbon Nanotube Composite Based High Frequency Nano Antenna

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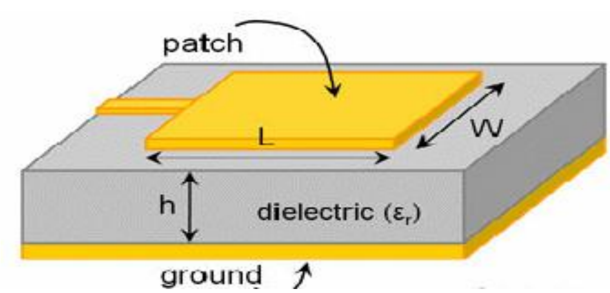
Abstrat

In this paper, we explore using carbon nanotube (CNT) Composite as material for high frequency antenna applications. We use Carbon-Nanotube Composite as the radiating element for a monopole antenna. An accurate electromagnetic model of the Carbon-Nanotube antenna is developed using Computer Simulation Technology microwave studio(CSTMWS) for numerical analysis. The return loss(S-parameters), radiation pattern and VSWR of the Carbon-Nanotube composite antenna are investigated. Results are shown for both copper and CNT antennas, and their performance is compared. It is observed that CNT composite is an effectively alternative to metal for the antenna structure.

1. Introduction

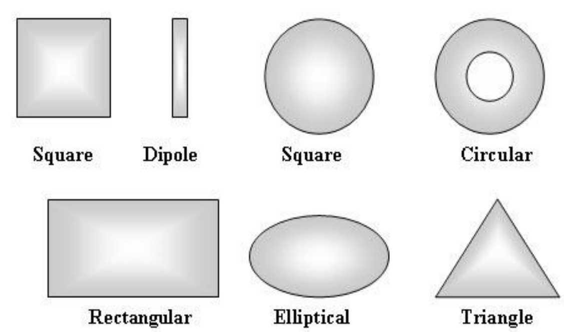
In its most basic form, a Micro strip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1.1

Figure 1.1 Structure of a Microstrip Patch Antenna



The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate .In order to simplify analysis and performance prediction, the patch is generally square, rectangular, Circular , triangular, elliptical or some other common Shape as shown in Figure1.2.

Figure 1.2[1] Common shapes of micro strip patch elements



Micro strip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger Bandwidth and better radiation [5]. However, such a configuration leads to a larger antenna size. In order to design a compact Micro strip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance.

II. Caaulation for designing of rectangular patch antenna

There are several theories that can be used to Analysis and design of rectangular micro strip patch Antenna like transmission line model, cavity model etc. In the purposed antenna follow transmission line model design technique. According to this model a rectangular patch of length L and width W can be viewed as a very wide transmission line that is transversely resonating, with the electric field is varying sinusoidal under the patch along its resonant length L. The electric field is assumed to be invariant along the width W of the patch. Furthermore, it is assumed that the antenna's radiation comes from the fields leaking out along out the width, or radiating edges of the antenna. Consider a Rectangular patch of Width W and Length L over grounded substrates with the thickness h and relative permittivity εr. For efficient radiator, a practical width that leads to good radiation efficiencies for fundamental TM10 mode is [1]

$$w = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Since some of the wave travel in the substrate and some in the air, an effective dielectric constant ε_{reff} is introduced to account for fringing and the wave propagation in the line and is given by [1]

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{-1}{2}}$$

Also it can be seen that the fields slightly overlap the edges of the patch making the electrical length of the patch slightly larger than its physical length. Thus a Correction term ΔL also called Edge extension is introduced in account for the fringe capacitance. This edge extension ΔL is given by [1]

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)}$$

Because of the fringing effect, the dimension of the patch along its length have been extended on each end by a distance L, so the effective length of the patch is given by [2]

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

Then actual length is given by

$$L = L_{eff} - 2\Delta L$$

After finding the actual length of the patch, the desired Rectangular Micro strip patch antenna is designed using Computer Simulation Technology microwave studio(CSTMWS) software is the industry-standard simulation tool for 3-D full-wave electromagnetic field simulation and is essential for the design of high-frequency and high-speed component design. After calculation and optimization for the desired output the specification for the rectangular patch antenna is given in table 1.

III. Design Parameters for high Frequency rectangular patch antenna

Here we design antenna for 5THz Frequency. Design parameter are calculated using above equation and given in table 1.

Table1.

Parameters	Units
Operating Frequency	5 THz
Patch Length	18.42 um
Patch Width	14.20 um
Patch Thickness	2um
Dielectric Material	FR-4
Dielectric Constant	4.3
Dielectric Substrate Height	1um

IV. Simulation of high frequency rectangular patch antenna

To simulate the rectangular patch antenna, all parameters of table 1 are used to design the antenna in CSTMWS software. In simulation one, Copper is used as the patch or radiation element for design are shown in figures 1.3 and for 5 THz frequency, and then CNT composite is taken for frequency 5 THz as shown in figure1.4.

Figure 1.3 DESIGN OF PATCH ANTENNA WITH COPPER AS RADIATION ELEMENT

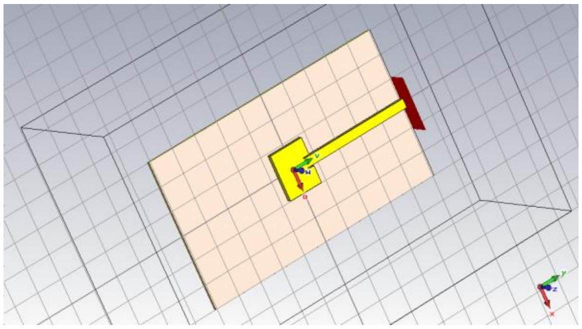


Figure 1.4 DESIGN OF PATCH ANTENNA WITH CNT COMPOSITE AS RADIATION ELEMENT

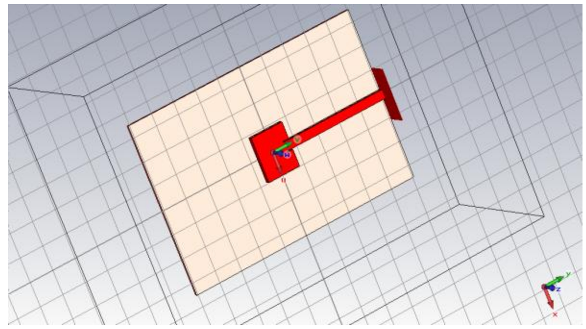


Figure 1.5 S-PARAMETER GRAPH OF COPPER PATCH ANTENNA

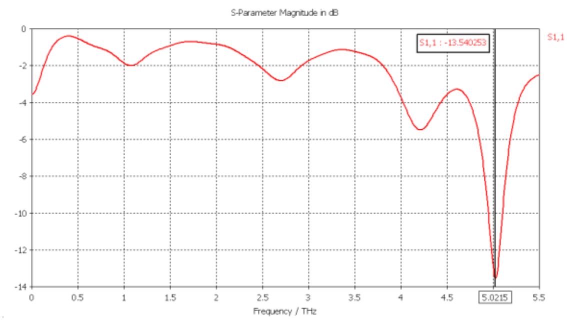


Figure 1.6 S-PARAMETER GRAPH OF CNT COMPOSITE PATCH ANTENNA

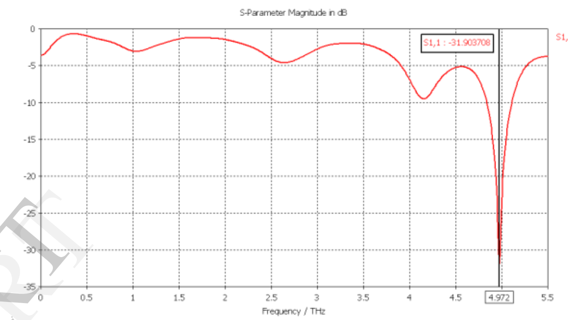


Figure 1.7 VSWR GRAPH OF COPPER PATCH ANTENNA

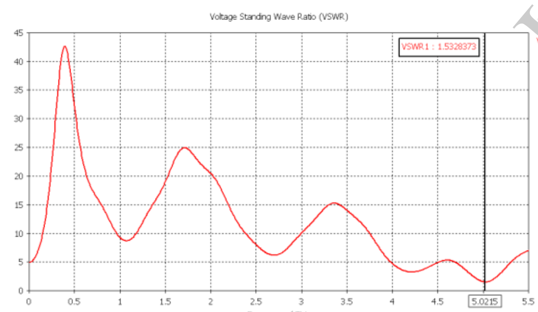


Figure 1.8 VSWR GRAPH OF CNT COMPOSITE PATCH ANTENNA

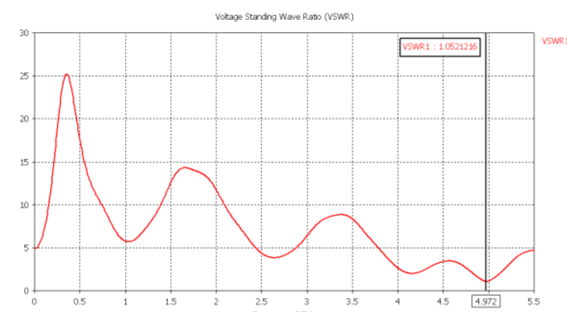


Figure 1.9 FAR-FIELD RADIATION OF COPPER PATCH ANTENNA

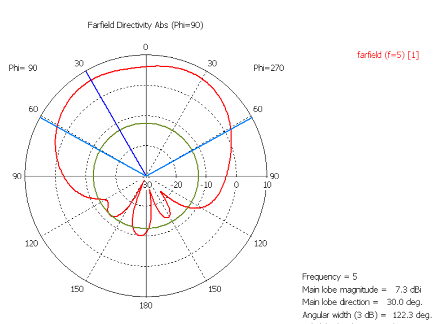
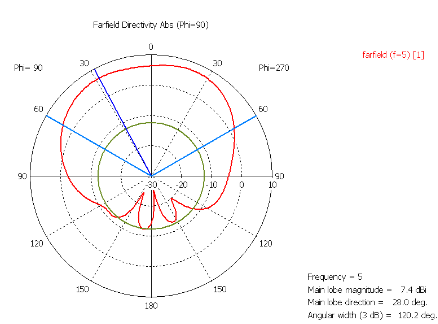


Figure 1.10 FAR-FIELD RADIATION OF CNT COMPOSITE PATCH ANTENNA



V. Compression of CNT Composite and Copper patch antenna

As per results obtained by simulating both copper and CNT as radiation element for a rectangular patch antenna it is very clear that CNT as radiation material has upper hand than copper. The results are compare In the table2. CNT have many flexibilities as a radiation material for antenna like its conductivity can easily adjusted by making CNT composites and it has a great thermal conductivity and tensile strength. The housing effect on the performance of the CNT antenna is much lower than for the copper antenna. Because of the presence of large kinetic inductance (due to large momentum relaxation time) in each CNT, the skin effect in CNT bundles is significantly reduced compared to that in conventional conductors.[1]

Table 2

Parameters	Frequency	Copper	CNT
Reflection coefficient	**5 THz**	**-13.014**	**-22.738**
VSWR	**5 THz**	**1.576**	**1.158**
Far Field Main lobe magnitude	**5 THz**	**7.4 db**	**7.3 db**
Minimum value of reflection coefficient for copper	**5.021 THz**	**-13.540 VSWR (1.5532)**	**-**
Minimum value of reflection coefficient for CNT	**4.972 THz**	**-**	**-31.904 VSWR (1.052)**

VI. Conclusion

In this paper the CNT composite is investigated as a very high frequency radiation material for antennas. This high frequency patch antennas can use as optical sensors and in many other high frequency operation with precision due to is good results regarding quality parameter VSWR .CNT composite can also be used as composite material in patch and for other antennas too for many more applications.

References

[1] Kalpesh R. Chudasama, Prof. Anupkumar, Prof. Vivek Ram, Prof. Sreenath kashyap" Design Of Carbon Nanotubes (CNT) Patch Antenna For WLAN Application" IJERT Vol. 2 Issue 4, April – 2013.

[2] H. Rmili, J.-L. Miane, H. Zangar, and T. Olinga, "Design of microstrip-fed proximity-coupled conducting polymer patch antenna," *Microw. Opt. Technol. Lett.*, vol. 48, pp. 655–660, 2006.

[3] I. Akyildiz and C. B. F. Brunetti, "Nanonetworks: A new communication paradigm," *Computer Networks*, vol. 52, pp. 2260–2279, 2008.

[4] K. Jensen, J. Weldon, H. Garcia, and A. Zettl, "Nanotube Radio," *Nano Letters*, vol. 7, pp. 3508–3511, November 2007.

[5] C. E. Koksal and E. Ekici, "A Nanoradio Architecture for Interacting Nanonetworking Tasks," *Elsevier Nano Communication Networks Journal*, vol. 1, pp. 63–75, March 2010.

[6] C. E. Koksal, E. Ekici, S. Rajan, "Design and Analysis of Systems Based on RF Receivers with Multiple Carbon Nanotube Antennas," *Elsevier Nano Communication Networks Journal*, vol. 1, pp. 160 172, September 2010.

[7] B. Atakan and O. B. Akan, "Carbon Nanotube-Based Nanoscale Ad Hoc Networks," *IEEE Communications Magazine*, pp. 129–135, June 2010.

[8] Jin Hao, *Member*, *IEEE*, and George W. Hanson" Infrared and Optical Properties of Carbon Nanotube Dipole Antennas" IEEE transactions on nanotechnololy, VOL. 5, No. 6, nov.2006

[9] G. W. Hanson,"Fundamental Transmitting Properties of CarbonNanotube Antennas" IEEE transactions on antenna and propagation VOL. 53, NO. 11, NOVEMBER 2005

[10] J. Zhang, N. Xi, K. W.C. Lai, H. Chen, Y. Luo, and G. Li, "Singlecarbon nanotube based photodiodes for infrared detection", Proc. ofthe 7th IEEE International Conference on Nanotechnology (IEEE NANO), pp. 1156 – 1160, 2007.
53, no. 11, pp. 3426 – 3435, 2005.

[11] Peter J. Burke, Shengdong Li, and Zhen Yu, "Quantitative theory of nanowire and nanotube antenna performance", *IEEE Trans. On Nanotechnology*, vol. 5, no. 4, pp. 314-334, 2006.

[12] King W. C. Lai, Ning Xi, Jiangbo Zhang, Guangyong Li and Hongzhi Chen, "Packaging carbon nanotube based infrared detector," Proc. Of the 7th IEEE International Conference on Nanotechnology (IEEENANO), pp. 778 – 781, 2007.