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Nano Composites Based Microstrip Antenna for Stealth Applications

K S Chaya Devi[1], Basavaraj Angadi[2], H M Mahesh[1*]

[1]Department of Electronic Science, Bangalore University, Bangalore-560056, India.
[2]Department of Physics, Bangalore University, Bangalore-560056, India.

Abstract

In this paper we explore using Nano composite material for radar stealth applications. An accurate Electromagnetic Model of the composite antenna is developed using 3D Electromagnetic high frequency structure simulator software (HFSS) for numerical analysis. Good agreement between computed results is shown for both copper and single walled carbon nanotube (SWCNT) based antennas. The SWCNT composite antenna shows stable Gain and radiation pattern over the X-band frequency range. The dispersion characteristic of SWCNT composite antenna shows its suitability for radar communication system. Using inset feed configuration, the results show that insertion of SWCNT nano composite microstrip patch antenna increases its operation bandwidth without considerable degradation in other parameters.

Keywords: Inset Feed, Nano-composites, micro strip antenna, radiation pattern

1.INTRODUCTION

A microstrip patch antenna consists of a flat rectangular metalized sheet mounted over a substrate with a ground plane. The configuration of microstrip patch antenna has numerous advantages like easy of fabrication, low profile, light weight, flexibility in design techniques and can be applied in communication applications such as traffic radars, military and aerospace systems. The design and development of microstrip patch antenna is the most prominent task in microwave communication systems to achieve the desired radiation pattern by replacing of metals to SWCNT composite materials.

Metals are commonly used in antenna structures for the radiating elements, feed lines, and ground plane. However, for diversified microwave communication applications,

[*] Corresponding Author: H M Mahesh, hm_mahesh@rediffmail.com

cost, fabrication procedure, weight, or corrosion resistance can limit the usefulness of metal antennas. Some recent studies have used various composite materials as replacement for metals [1-5]. Here SWCNT –composite patch antenna is proposed, PAni-NSA with SWCNT (polyaniline- Napthalene sulfonic acid with SWCNT) have been used to make a highly conductive microstrip patch antenna , these X-band antenna systems are in increasingly used in military applications such as automotive radars, high resolution radars and stealth applications [6,7].

In this paper, we have explored the use of SWCNT composite materials for X-band microstrip antenna bandwidth enhancement. The inset fed microstrip antenna configuration operating over 9.5GHz to 10.5GHz is designed and investigated by numerical simulation by using 3D Electromagnetic HFSS software tool.

2. DESIGN

As our requirements is to design an antenna with an inset fed microstrip line feed configuration for X-band frequency range. As both the radiating element and feed on the top of the substrate are on the same layer care is taken to avoid spurious radiations of the feed. Otherwise this will increase the side lobe levels and cross polarizations.

2.1 Design specifications and procedure:

Freuency : 9.5-10.5 GHz

Substrate: RT Duroid 5880

Height: 0.787mm

Dielectric constant: 2.2

(a) Design of rectangular patch :

The width and length of the patch antenna are calculated by using transmission line design equations.

The width of the patch is given by

$$w = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_{r+1}}} \tag{1}$$

Actual length of the patch is determined as

$$L= \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} - 2(\Delta l) \tag{2}$$

The input resistance for the inset- feed is given by

$$R(y=y_0) = R\,(=y_0)\ \mathrm{Cos2}[\frac{\pi y0}{L}] \tag{3}$$

Using the above formulas, the calculated values of width and length of rectangular microstrip patch for RT duroid substrate of dielectric constant 2.2 modeled and optimized in 3D electromagnetic HFSS software.

2. Results and discussion

2.1 Microstrip *PAni-NSA with SWCNT* patch antenna

The antenna designed for the requirements such as, 10 GHz operation frequency, 50 Ohms feed line, minimum return loss of 14 dB and minimum gain 5 dB using the design method and choosing inset feed microstrip-line configuration and substrate Rogers 5880 with thickness 0.787 mm as shown in figure 1.

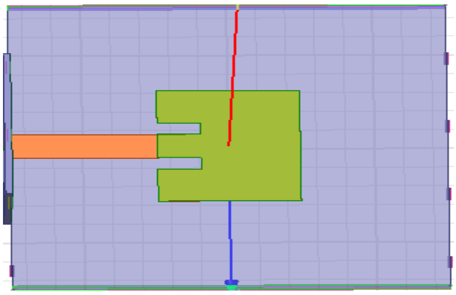

Figure 1: Microstrip PAni-NSA with SWCNT patch antenna

Figure 2 shows the variation of Return loss verses frequency plot of a SWCNT nanocomposite patch antenna, the impedance bandwidth over return loss less than the -10dB is measured from 9.5 GHz to 10.5 GHz band. From the figure 2, it is seen that the antenna resonates at 10 GHz of frequency, which is close to the designed frequency of 10 GHz with a minimum return loss of -20 dB. From this graph upper frequency (f_H) 10.08 GHz and Lower frequency (f_L)is 9.89 GHz of the band respectively when its return loss reaches -10dB, f_r is the centre frequency between f_H and f_L. The impedance bandwidth of conventional Rectangular microstrip antenna is found to be 2.60%.

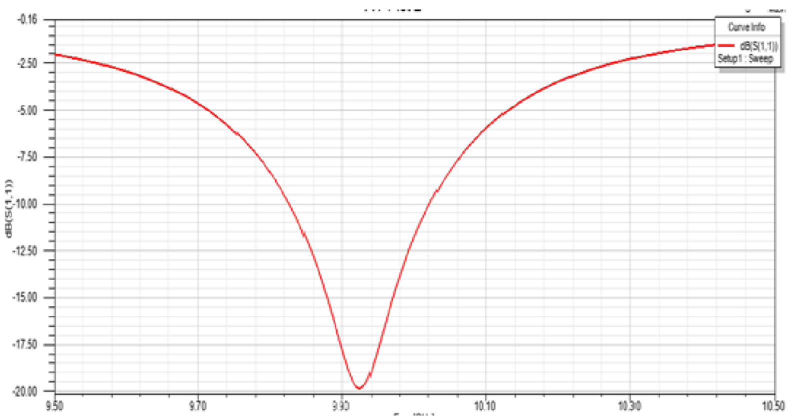

Figure 2: Simulated return loss of PAni-NSA with SWCNT patch antenna

The antenna radiation pattern was also measured through simulation, which resulted in the diagram presented in figure 3. The co-polar radiation patterns of the PAni_NSA with SWCNT are simulated at the frequency of 10GHz, from the figure it can be observed that the co-polar patterns are broadsided and linearly polarized. The -3dB half power beamwidth (HPBW) of PAni_NSA with SWCNT is 71˚. Hence it is clear that the PAni_NSA with SWCNT improves sharpness of beam and suppresses the maximum back radiations, which in turn sharpens the beam and hence improves the radiation patterns.

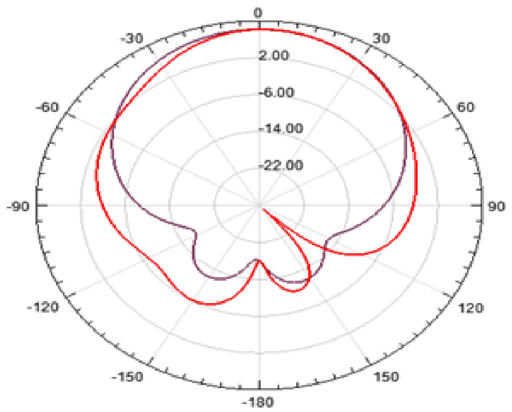

Figure 3. Simulated radiation pattern of the *PAni-NSA with SWCNT* antenna

3. CONCLUSION

SWCNT –nano composite Patch antenna was designed and simulated at the resonating frequency of 10GHz. The SWCNT nano composites antennas such as the *PAni-NSA with SWCNT* composite antenna enhancement of the bandwidth of 2.60% compared to the conventional patch antenna. The radiation pattern and antenna gain were found that is 8.53dB. The above result shows that a suitable design of SWCNT Nano composites patterns has almost no effect on the performance of the other antenna parameters compared to conventional patch antenna. The configuration of microstrip patch antenna has numerous advantages like easy of fabrication, low profile, light weight, flexibility in design techniques. In conclusion, SWCNT nano composite antenna can be applied in stealth applications such as aircrafts or warships**.**

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