# Investigation of Conformal CPW fed Copper and Multiwalled Carbon nanotube microstrip antennas in X- Band Applications

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**Abstract:** *This paper, describes the characteristics of flat and curved antenna structures using copper and Multi-Walled Carbon Nanotube (MWCNT) materials. A flexible dielectric substrate, polyimide material with dielectric constant εr= 3.5, tan δ = 0.008,the thickness of 0.1mm, is employed here. The low thickness of dielectric material allows it to be mounted on curved surfaces. The CPW fed conformal structures are designed to resonate at 10 GHz in the X-band (8GHz - 12GHz).Cylindrical curvature structured antennas designed with different radii (10mm, 15mm, and 20mm), and investigated their performance interims of return loss (S11), bandwidth, gain, and radiation efficiency, etc. Here a thin film MWCNT antenna is prepared by using a spin coating technique. The analysis of comparative study for both planar and flexible antennas are carried out in the present investigation. Both simulation and fabrication results are in close agreement with each other. From the experimental results, the planar and conformal antennas(copper and MWCNT)offer approximately the same impedance bandwidth around 33%but antenna gains is reduced from flat to curved structures of different radii 15mm in the intended direction. Material resonant properties and feeding techniques allow to enhance impedance bandwidth. The resistivity of the conductive material used in the antenna design increases as the bending angle is increased, this leads to a gradual increase in beam width and hence a drop in gain within the operating band of frequencies. The MWCNT antennas are suitable for low-power communication applications and ingas and harsh chemical environments where conventional materials get effected. Conformal antennas are widely employed in satellite, automobile and defense, Synthetic aperture radar applications.*

*Keywords: MWCNT, Conformal, CPW fed, impedance bandwidth, X-band*

## I INTRODUCTION

A promising methodology for the development of e lectronic and electromagnetic subsystems with vari ous factors of printed flexible electronics. An advantage of printed electronics has rapid prototyping, ultra-low-cost, roll-to-roll manufacturing, and low-temperature processing, on bendable plastic substrates. The electronic materials that can print on flexible thin substrates were exploited for radio frequency (RF) communication components such as switches [1], filters [2], transistors [3], and antennas [4–7]. Among several antenna types, microstrip antennas are especially attractive for several wireless applications, because of their low profile, low cost, simplicity, flexibility to bent surfaces, and flexibility in design [8]. The adaptability of the substrate improves a degree of freedom in the design of antenna, since the substrate can be integrated on bended surfaces as a conformal antenna. For Instance conformal antennas differ from avionics antennas, where the flexible antenna conform to the curved surface of an aircraft decreases the aerodynamic drag [9], to wearable antennas, where flexible antennas offer the freedom to design light weight, body-worn, and less visually interrupting[10].The variation in the antenna parameters are due to bending or stretching [11]. Advanced nanomaterials like carbon nanotubes (CNT) have played a significant role as the new candidate for designing the antenna and RF devices, particularly in harsh chemical and gas environments. CNT and its composite have arose many research interests due to they have good electrical properties, such as density is half and thermal conductivity is, ten times of the copper material. Its semi conductive and metallic properties can be controlled and modified through the growth or preparation of either single-wall or

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multiple-wall samples. [12]. The electrical performance of the carbon nanotubes resistive and conductive properties under bending and verify the radiation parameters of the antenna, when the bending increases the surface resistance is increase and conductivity reduces [13] The CPW feeding method offers wider impedance bandwidth, it has less coupling, more lossy and low Q- factor, as a result, enhances bandwidth [14].

In this work planar, and Cylindrical curvature structured antennas with radii 20mm, 15mm, and 10mm conformal antennas are designed and fabricated using copper and MWCNT thin films placed on the flexible polyimide substrate. These MWCNT models are fabricated using the spin coating method. The performance characteristics of the above antennas are analyzed using a vector network analyzer.

The work is presented in sections I, II is an introduction and device fabrication, section III illustrates the results and discussion, and conclusions are made in section IV.

## II ANTENNADESIGN

MWCNT is a high current carrying conductive material, which is used in the patch antenna in the present work. The MWCNT consists of large nano-bundles, called fundamental resonators. These fundamental resonators radiate the electromagnetic waves, and the current passing through the patch edges includes extra resonance, which leads to an increase in the antenna resonance behavior, hence enhanced impedance bandwidth [15, 16]. The MWCNT prepared solution was deposited on polyimide dielectric substrate with a fully optimized rotating speed of 3000 rpm, 60 sec in a spin coater. A SMA connector was soldered to the microstrip feed line. The rectangular MWCNT patch antenna was fabricated, and designed dimensions for X-band frequency range (8-12) GHz.

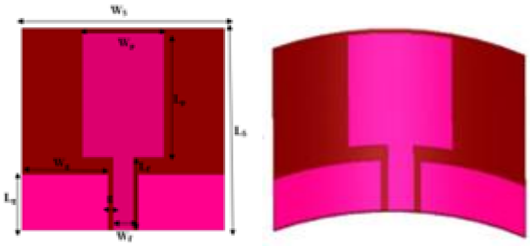
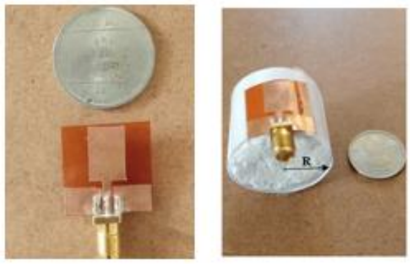


Fig. 1 Copper Simulated antenna models with curvature radii (a) R= Planar (b) R=15mm conformal antennas



(a) (b)

Fig. 2. Fabricated Copper antennas (a) planar antenna (b) R=15 mm conformal antenna

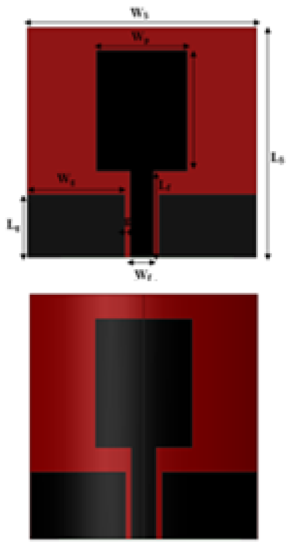
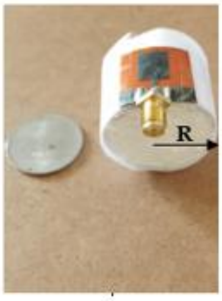


Fig. 3 MWCNT Simulated antenna models with radii (a) R= Planar (b) R=15mm conformal antennas




(a) (b)

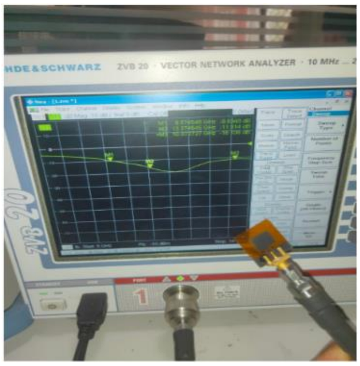
Fig. 4 Fabricated MWCNT antennas a) planar antenna (b) R=15 mm conformal antenna

## III.RESULTS AND DISCUSSION

In this section, copper and MWCNT antennas with polyimide substrate as dielectric material is analyzed .Antenna dimensions for different antennas considered in this work are tabulated in Table. 1. These antennas are designed with the help of ANSYS HFSS software.Fig.1to Fig. 4shows the geometry of flat and conformal antenna structures made up of copper and MWCNT, for different curvatures. Curved surfaces with radii ∞, 20mm, 15mm, and 10 mm are considered for analysis. Fig. 5 and 6 illustrate the measurement of return loss using ROHDE&SCHWARZ ZVB 20-vector network analyzer. Fig.6 depicts the antenna gain measurement setup.

Fig. 9 and 10 shows the gain versus frequency plots and are summarized in TableIII. It can be observed that with the decreasing radius of the flexible structure from planar to 10mm, the gain of the copper-based antenna reduces from 3.7 dB to 2.4 dB for simulated models, and from 3.3 dB to 2.1 dB for fabricated models. Whereas for MWCNT simulated models it is from 2.7 dB to 1.4 dB, and for fabricated models, it varies from 2.3 dB to 1.2 dB with an increasein the bending of the conductive material on the antenna, increases the resistance of the patch material, which inturn has a negative impact on conductive behavior of the material.With a decrease in the curvatureradii, thesurface resistivity increases and hence conductivity decreases as a result gain is reduces and the half-power beamwidth is increased, [13, 17].

Fig. 16 to 17 illustrates simulated radiation efficiency plots for both materials considered in this work. Fig. 18 to 19 shows the 2D radiation patterns of the simulated antennas.Impedance bandwidth and gain comparison of the existing study with the current study are tabulated in Table III



(a)

(b)

Fig.5 (a, b) MWCNT antenna reflection coefficient measurement setup

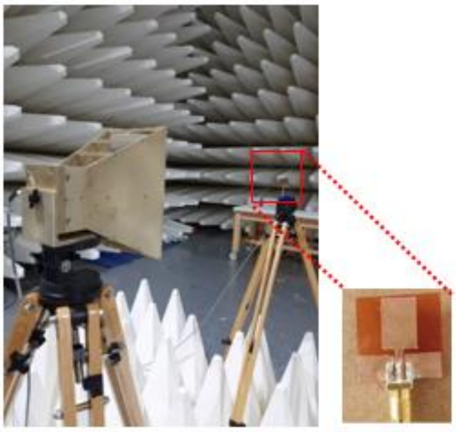


Fig.6 Antenna gain measurement setup

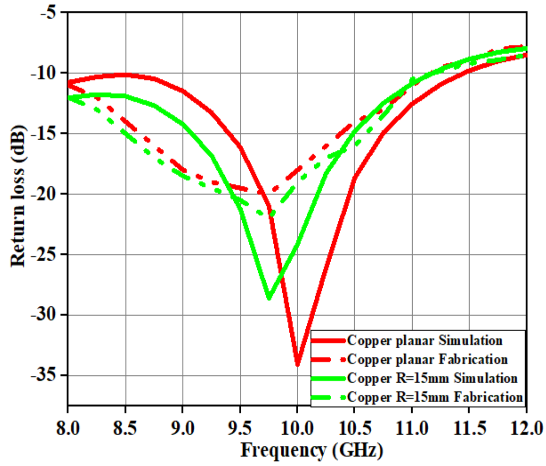



Fig. 7 Returnloss comparison o Copper planar and R=15mm simulation and fabrication antennas

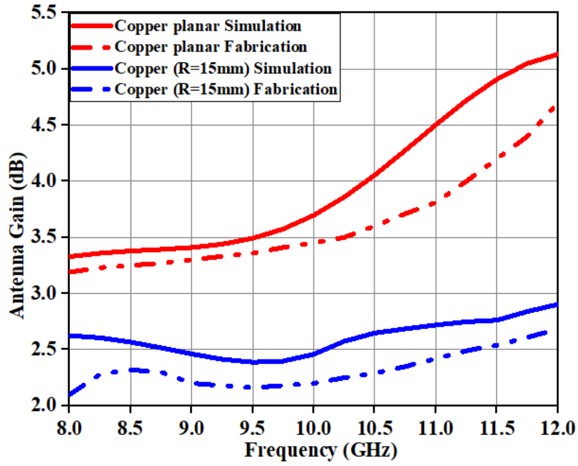



Fig. 9 Gain versus frequency comparison of copper planar and (R=15mm) simulation and fabrication antennas

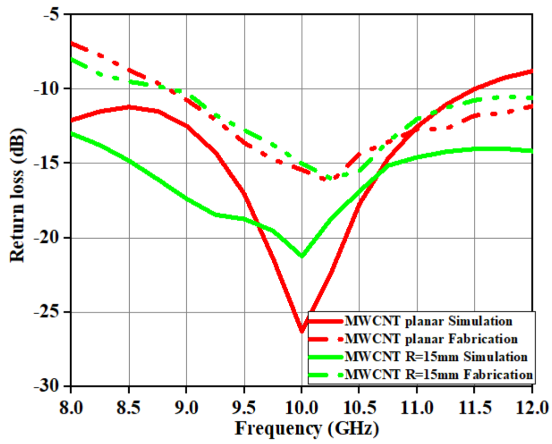



Fig. 8 Returnloss comparison of MWCNT planar and R=15mm simulation and fabrication antennas

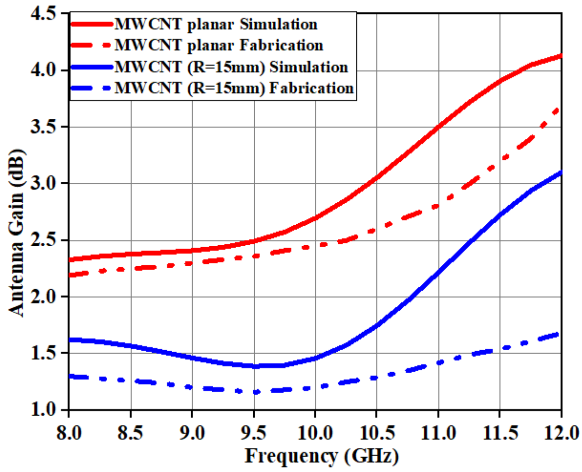



Fig. 10 Gain versus frequency comparison of MWCNT planar and (R=15mm) simulation and fabricationantennas

Table. I Dimensions of CPW fed patch antenna

| Parameter | Dimensions (mm) | |
|---|---|---|
| | Planar Copper and MWCNT antennas | Conformal Copper and MWCNT antennas |
| Rectangular patch width ($W_f \times L_f$) | 8 X 11 | 8 X 11 |
| Microstrip feed line width and length ($W_f \times L_f$) and gap (g) | 2X7.5 | 2X7.5 |
| Substrate width and length (Ws×Ls) | 20X20 | 20X20 |
| Ground plane width and length ($G_w \times G_L$) | 8.5 X5.5 | 8.5 X5.5 |

Table. II Comparison of performance current study with existing work.

| S. No. | Antenna | Frequency [GHz] | Gain [dB] | Bandwidth | References |
|---|---|---|---|---|---|
| 1. | Standard patch antenna | 10 | 8.3 | 2.1% | [16] |
| 2. | MWCNT patch antenna | 10 | 0.8 | 20% | [15] |
| 3 | SWCNT Conformal antenna | 11 | 7.32 | 8% | [12] |
| 3. | MWCNT conformal antenna | 10.3 | 1.8 | 33% | Current study |

## IV. CONCLUSIONS

In this paper, the performance of planar and curved antennas placed on cylindrical structures with different radii of 20mm, 15mm, and 10mm is studied. Here conformal Copper and MWCNT rectangular patch antennas are designed and analyzed in the X-band frequency range (8 GHz - 12 GHz). The spin coating method is utilized to fabricate the CNT based CPW fed patch antenna. Various antenna parameters such as return loss, impedance bandwidth, gain, and radiation efficiency are compared. Both copper and MWCNT based antenna simulation and fabrication results are in close agreement with each other. The current study reveals that MWCNT based antenna achieves more impedance bandwidth with a sacrifice in the antenna gain. MWCNT based patch antenna shows an improved impedance bandwidth of about 32% in the frequency range of 8.6 GHz - 12 GHz compared to standard copper-based patch antenna. Curvature effects are on impedance bandwidth is observed to be quite negligible, the reason may be due to the effect of coplanar waveguide feeding technique and resonant performance of the materials used. But it has a negative impact on the gain profile, the reason may be due to the curvature effect in the antenna design. The proposed CPW fed MWCNT conformal antennas are suitable for satellite, automobile, defense, and Synthetic aperture radar applications. The future course of work is concentrated to improve the gain of the proposed antenna.

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