Computational Design and Performance Evaluation of Green Painting Absorbing Material

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Abstract— Microwave absorbing materials have received great attention in recent years for both civil and military fields due to various applications in communications, radar, satellite systems, and anechoic chambers. Wireless communication is currently the fastest growth of telecommunication technology. Many studies have indicated that there are harmful radiations produced by transmitting telecommunications structures. Effects on human exposure include dizziness, nausea, vomiting and loss of breath. A way to reduce strong microwave radiations for human is by applying a microwave absorbing paint coating to the wall of the built spaces. The green painting mixed with ingredients from coconut shells is the main material that is analyzed in this research. The findings show that material applied with the green painting can readily absorb the microwave radiations. The wave-absorbing materials are designed by using Computer Simulation Technology (CST) Microwave Studio simulation software. The goal of this simulation is to find the best performing absorber. From dielectric constant value, the modeling and simulation stage of microwave absorber are executed to obtain the reflectivity or S_{11} result using CST Microwave Studio software. Analysis of the S_{11} results and measurement of absorber performance are evaluated to define the microwave absorber performance. A free space measurement setup operating in the frequency of Ku Band is employed to measure absorption. The results show that the green painting with coconut based carbon can be used as coating absorbing material. Each material applied with the green painting shows excellent absorption at 3 to 6 dB range. The most excellent result is shown by double layer coating absorption up to 17 dB.

1. INTRODUCTION

Microwave absorbing materials (MAM) have received great attention from recent years is due to various applications in communications, radar, satellite systems, and anechoic chambers [1–4]. In the anechoic chamber, the electromagnetic wave absorber (EM) is used to absorb the reflected waves that occur in the chamber wall.

Interest in the study of absorbing materials has increased as broadband applications for the system to move towards the high frequency domain. In some cases, for example in modern airborne applications, the transmission network may be required to send certain commands only while pressing the EM wave in one direction to the other direction. Therefore, a suitable absorbent material with absorption characteristics that maintained over the entire operating frequency to be necessary for this system [5, 6].

In the use of absorption, MAM is divided into two types, i.e., coating and structure. The type of coating principle is that the high loss materials coating on the surface of the target can absorb the incident wave and reduce the return loss. Meanwhile, the type of structure is to reduce the reflection by matching the impedance and absorbing materials [7]. This paper emphasizes the type of coating of MAM.

During working with a short impulse signals in a wide frequency range, it is necessary to use effective ingredients that work in various wavelengths. In most instances, the construction of the absorber, ferrite is used to coat the absorber. However, at present, a number of alternatives design have been applied such as carbon fillers and metallized geometrical [2].

Microwave has the ability to cause biological damage through heating effects. Researchers have found that symptoms may effects on human exposure such as headache, nausea, fatigue, brain activity and loss of concentration [8]. In order to avoid the circumstances, a research on the use of paint to absorb wave radiation is performed. The mixture of paint and ingredients from coconut shells are the main materials that are studied in this research.

2. ABSORBER MATERIAL

The purpose of this study is to investigate the application of based carbon coconut shell as absorption of microwave radiation coating material. Considering a normal incident on the surface of absorbing material coated on perfect conductor. The absorption or reflectivity in dB unit is defined as:

$$R = 20\log|\Gamma| \tag{1}$$

where, the reflection coefficient, Γ

$$\Gamma = \frac{Z_i - 1}{Z_i + 1} \tag{2}$$

where, the characteristic input impedance, Z_i

$$Z_i = \sqrt{\frac{\mu_r}{\varepsilon_r}}\tanh(-jk_0 d\sqrt{\mu_r\varepsilon_r}) \tag{3}$$

where, d is the thickness of absorbing material and k_0 is the wave numbers in free space [9].

The green paint absorbers based on carbon powder coconut shell are fabricated and coated with three difference materials which are elephant board (0.5 mm thickness), plywood (3 mm and 18 mm thickness) and cement block (35 mm thickness). The complex permittivity and permeability of the absorbing material are the basic parameters which reflect the interaction between the electromagnetic wave and material. The simulation of coated absorber is executed to get the S_{11} result using Computer Simulation Technology Microwave Studio (CST MWS) software. The free space reflectivity measurements using arch method is applied to define the absorption performance. Figure 1 shows the setup of absorption measurement.

The similar methodology is repeated for the design of double layer absorbing material which is based on carbon powder and carbon granular of coconut shell. In the measurement of double layer absorbing material, only the elephant board coated is performed.

3. RESULTS AND DISCUSSION

The absorbing material is designed using CST Microwave Studio simulation software. Performance of the absorbent material can be predicted using CST software with the added value of the epsilon or dielectric constant. Figure 2 shows simulation results of predicted performance of absorbing material with varying the epsilon value. The lower the value of epsilon indicates the better the absorption performance.

The measurement of absorber is conducted to determine the performance of four different absorbent materials. Figure 3 shows the absoption of elephant board coated material. The evarage absorption is −3.5 dB and the maximum absoption is 5.1 dB at 11.4 GHz.

Figure 4 shows the absoption of plywood coated material (3 mm thickness). The average absoption is −2.8 dB and maximum absorption is −3.3 dB at 10.86 GHz.

Figure 5 shows the absoption for plywood coated material (18 mm thickness). The average absoption is −3.5 dB and maximum absorption is −6 dB at 9.16 GHz.

Figure 6 shows the absoption of cement block coated material (35 mm thickness). The average absoption is −3.2 dB and maximum absorption is −6 dB at 9.06 GHz.

From Figures 3, 4, 5 and 6, the absorption is about 3 dB in average. This shows that the four different absorbent materials have performed the similar absorption performance.

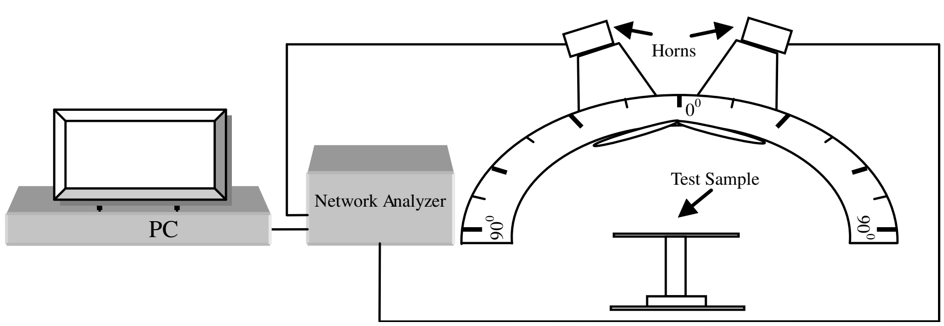

Figure 1: The setup of absorption measurement.

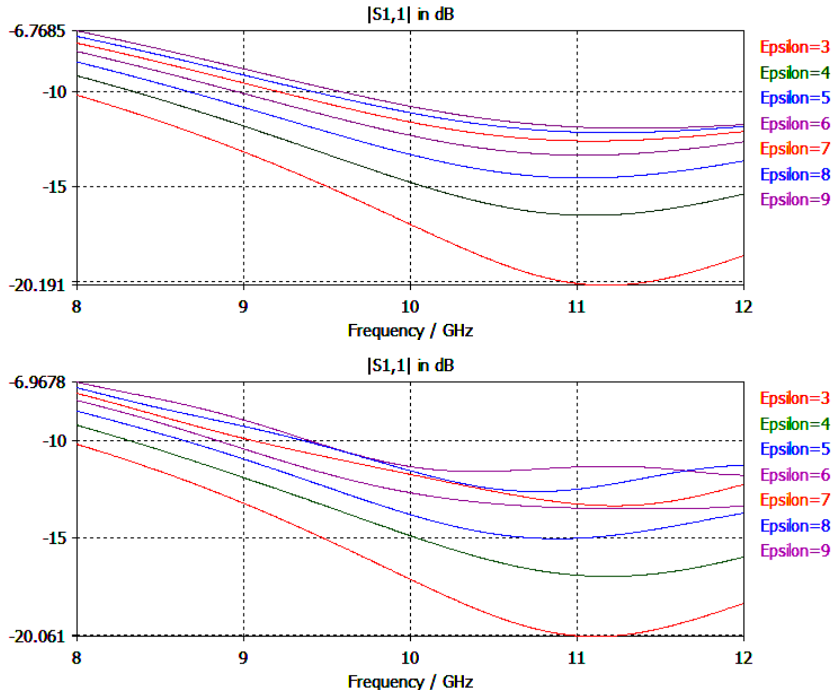

Figure 2: S_{11} simulation results of absorbing materials for epsilon 3 to 9 (a) 1 mm to 3 mm, (b) 18 mm to 35 mm.

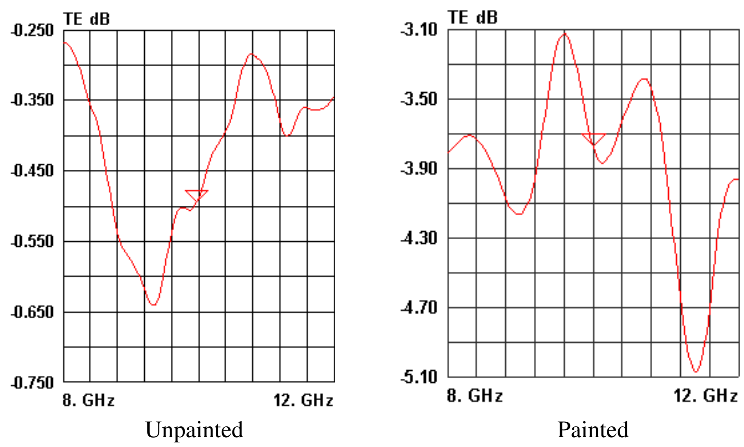

Figure 3: Measurement results of elephant board coated material.

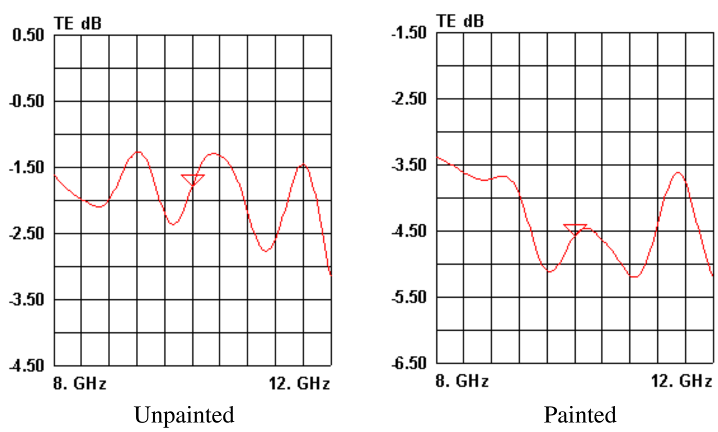

Figure 4: Measurement results of plywood coated material (3 mm thickness).

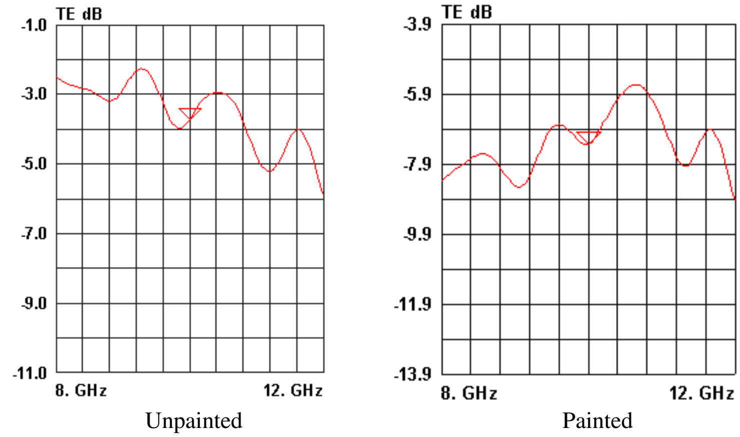

Figure 5: Measurement results of plywood coated material (18 mm thickness).

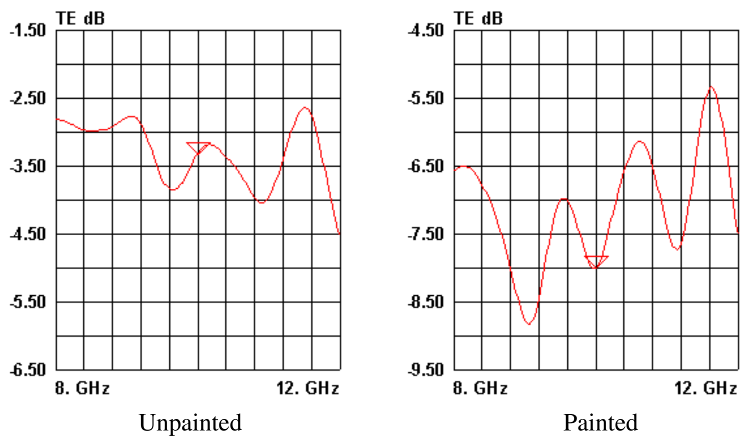

Figure 6: Measurement results of cement block coated material.

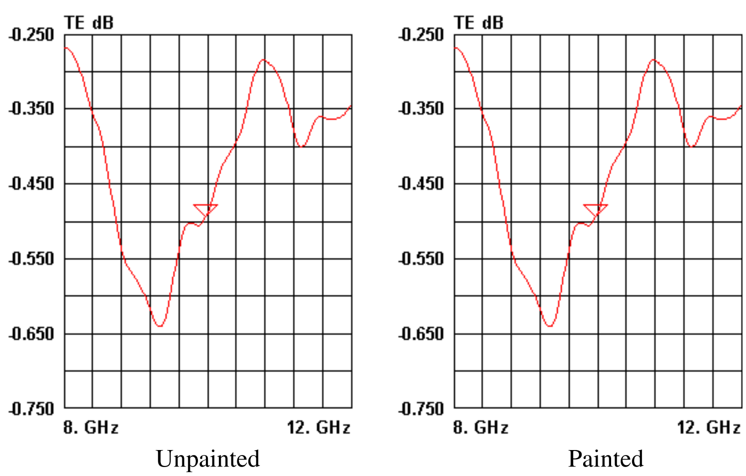

Figure 7: Measurement results of double layer absorbent material.

Figure 7 shows the absorption of double layer absorbent material. The average absoption is 12 dB and maximum absorption at is 17 dB at 10.02 GHz. This shows that the double layer absorbent material has resulted better absorption performance.

4. CONCLUSIONS

A new green paint absorbing material based on coconut shell is analyzed in this paper. The results show that material applied as coating material can absorb the signal. The average absorption for single layer is about 3 dB. It also shows that any material used contribute the same absorption performance when applying green paint absorbing material. The double layer absorbent material shows better absorption with 12 dB in average and maximum absorption is 17 dB at 10.02 GHz. For future improvement, further experimental works have to be carried out in determining significant contributing factors to improve the absorption performance.

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