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Study of the Electromagnetic Characteristics of a Rectangular Microwave Absorber Based on Metamaterial

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Abstract: *The recent researches on the microwave systems show a big development in level of the performance such as the miniaturization of circuits, and the reduction in congestion, but there are always constraints during the design and construction. To solve this kind of problem, a study of the electromagnetic characteristics of these devices allows us to offer a good design. In this article, an absorber rectangular microwave will be studied, this study is based on the determination of the reflection and transmission coefficients. We are going to use metamaterials to control the electromagnetic parameters of this absorber, the substrates used are dielectric type in order to have a reciprocity of the overall structure .Since there is no theoretical or experimental results in the literature of this kind of complicated structure, we were forced to do stimulation through the help of a software known as HFSS.*

Keyword: *Absorber; Dielectric; Electromagnetic; HFSS; Metamaterial; Microwave;*

1. INTRODUCTION

During the Second World War, several electronic circuits, particularly those used in telecommunication systems, were created and developed in the United States and Germany. The performance of military systems, such as radar and antennas are estimated according to the physical materials include absorbers electromagnetic where they gather at a painting or an effective coating for all polarizations over a wide frequency band and a wide range of impacts.

Electromagnetic absorber can be classified into several categories, among it, the one that is studied and used in various electronic systems, we note the dielectric absorber [1] and the magnetic absorber [2, 3]. Today, physical absorber and especially for Microwave circuits and systems is based on a new material that is known as « metamaterial».

Metamaterials form a special class of structured artificial materials that represent new electromagnetic properties that do not exist in nature. In 1968, an analysis of this kind of structure was made originally by the Russian physicist Victor Veselago [4], he proposed that the metamaterials have different properties compared to conventional media, such as a negative refraction, reversal of the Doppler effect and Cherenkov radiation .These properties can be divided into two broad classes; physical and geometric.

These physical properties of the metamaterials like the nature of the permittivity (ε) and the permeability (μ) [5] and the geometric properties such as the resonators dimensions [6, 7] that represent the indispensable tool for the study of the new structures and microwave circuits. In the last decade, the various works on radar systems are based on the use of metamaterials, in a particular way, we note the metamaterials absorber because this kind of device is more effective for stealth technology.

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In this work, we are going to present electromagnetic absorber of a rectangular type based on metameterials. These are introduced into the design of our absorber using (SRR) Split Ring Resonators; these resonators have a magnetic resonance [8] and also a negative refractive index [9]. A study of the electromagnetic characteristics of our absorber will be proposed in order to have the necessary design performance.

2. DESIGN METHODOLOGY

2.1 Dielectric absorber

The absorber dielectric can be obtained by using two drivers conductor plans, between them we put the dielectric substrate which is the Alumina 96% of the physical characteristics ($\varepsilon_r = 9.4$) with dielectric loss tangent ($\theta = 0.006$) and geometric characteristics (h = 0.635 *mm* and δ = 3.6 *mm*). All the components can be represented by a rectangular cavity as shown in the Figure 1:

The thicknesses of the two copper conductors do not have importance. By choosing the dimensions of the cavity so that (Δy = 0. 2 *mm*). By polarizing the structure with a wave plane where the electric field is according to $(\overrightarrow{Ox})$ axe. Absorption for our structure is given by the following relationship (with $S_{21} = 0$) [10]:

$$A_b = 1 - |S_{11}|^2 \qquad (1)$$

The Simulator HFSS gives us the electromagnetic characteristics of our absorber dielectric as the following:

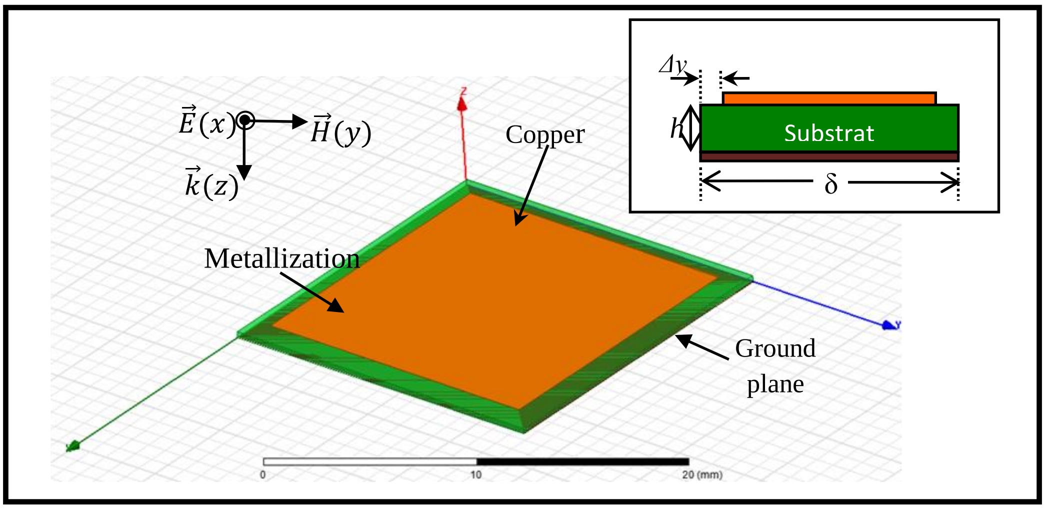

Figure 1 Representation of the rectangular dielectric absorber on the 3-Modeler HFSS.

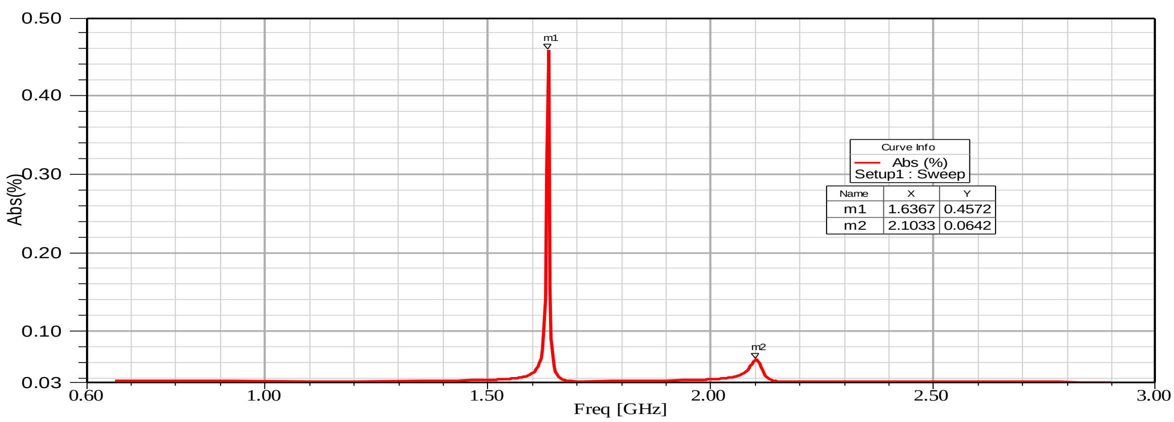

Figure 2 Electromagnetic characteristics of the rectangular dielectric absorber.

2.2 Metamaterial Absorber

2.2.1 Electromagnetic characteristics of the rectangular (SRR)

We are going to use Split Ring Resonators (SSR) to form rectangular shape to control the absorption parameters for our metamaterial absorber. A metamaterial rectangular resonator engraved on a substrate of Alumina 96% from previous dielectric characteristics is represented by the Figure 3:

The polarization of our resonator metamaterial that has dimensions represented by the table below and the application of the boundary conditions on the HFSS by electric and magnetic walls allow us to get the response of our structure as shown in Figure 4.

The dimensions of the structure with the resonator (SSR) are selected (using the period *P*) to have a superior magnetic resonance at the absorber dielectric resonance. The thickness of the two rings of the (SSR) is in the order of 5μm.

TABLE I (SSR) RECTANGULAR DIMENSIONS.

Dimensions	***P***	***r***	***R***	***c***	***d***	***l***
Values (*mm*)	3.6	0.8	1.4	0.2	0.2	0.2

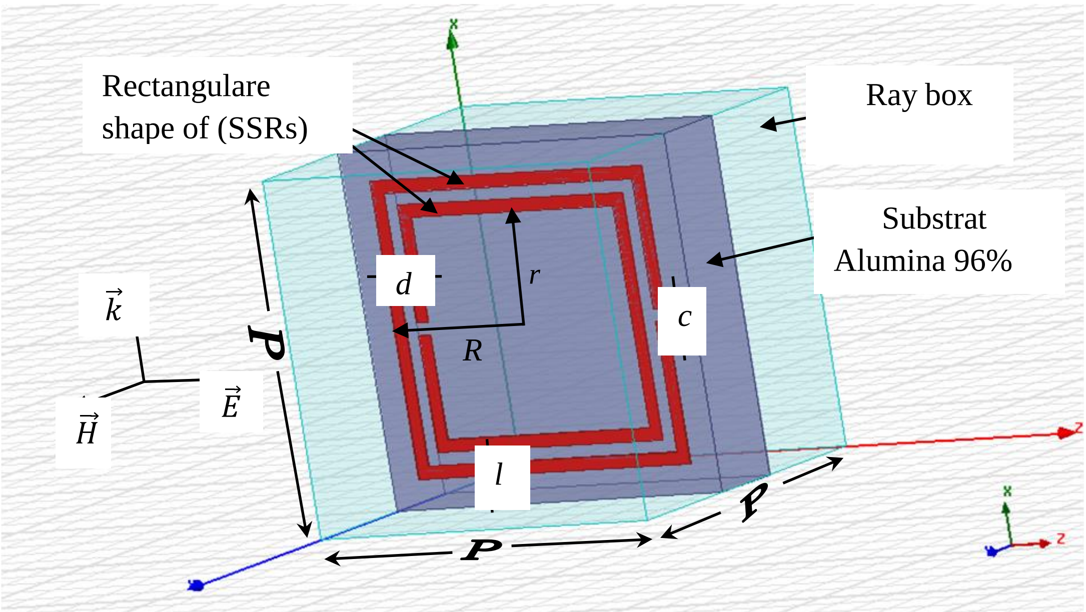

Figure 3 Polarization of (SSRs) rectangular under HFSS according to z.

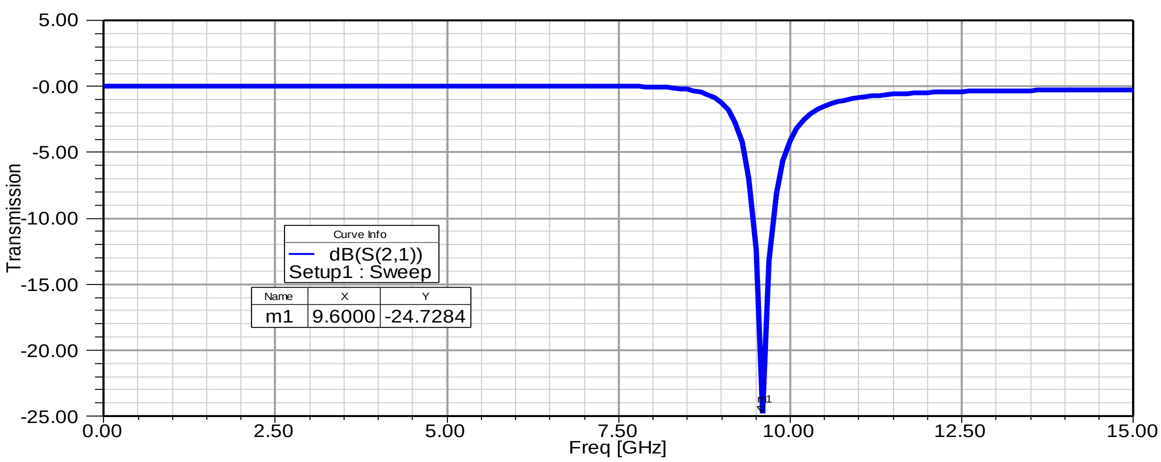

Figure 4 Transmission of (SSR).

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2.2.2 Prototypes of the metamaterial absorber

In this section we propose two metamaterial absorbers that have respectively two and four circular (SSR) resonators of the same dimensions given in Table1. The metamaterial resonators are engraved on the same dielectric substrate of the same physical characteristics and thickness (h = 0.635 mm). Geometric shapes of each absorber can be represented in figure below:

The Metamaterials resonators are engraved on the substrate of the alumina 96%, so that the interruption of the outer ring of each (SSR) is directed to the other and the reciprocal for the inner rings. On the Simulator HFSS, we can visualize the following electromagnetic characteristics:

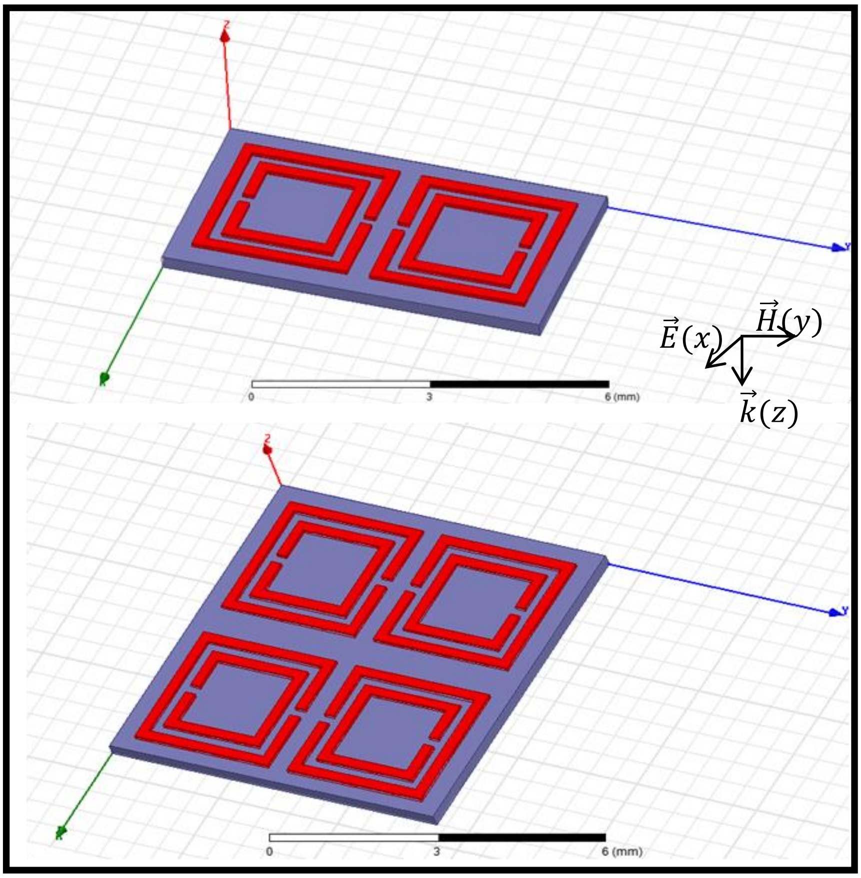

Figure 5 Prototype of the metamaterial absorber (a) (1 × 2) network, (b) (2 × 2) network.

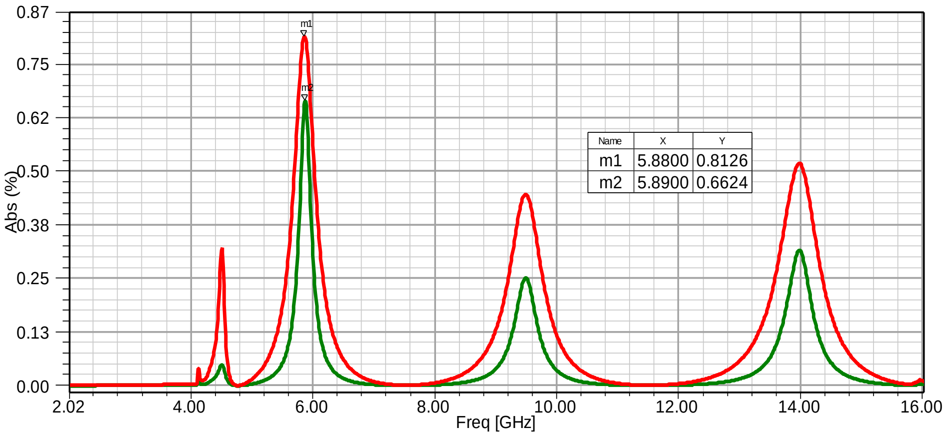

Figure 6 Electromagnetic characteristics of the metamaterial absorber for both networks.

3. DISCUSSION OF RESULTS

We can summarize the results in the following table:

TABLE II ABSORBER ELECTROMAGNETIC CHARACTERISTICS: DIELECTRIC AND METAMATERIAL.

Electromagnetic characteristics		Abs (%)	f_r (Ghz)	h_λ
Dielectric absorber		45.72	1.63	λ /438
Metamaterial absorber	Network (1×2)	66.24	5.88	λ /122
	Network (2×2)	81.26	5.89	λ /121

The above table gives us the various electromagnetic characteristics for the two types of absorber; dielectric and metamaterial. We note that the electrical resonance of the absorber dielectric is lower towards the magnetic resonance of the absorber metamaterial, we note also that the percentage of absorption for Metamaterials (especially for a high number of resonators) is highest (81.26%) compared with the dielectric absorption (45.72%). The approximate thicknesses to the various resonances for the two types of absorbent are also different from the other.

4. CONCLUSION

A study of the electromagnetic characteristics of metamaterials absorber for a rectangular shape has been proposed in this work. To show the effect of metamaterials on the electromagnetic absorption phenomenon, we have also investigated dielectric absorber in the form of a rectangular cavity, a comparison of the characteristics between each absorber which is proposed, these lasts which have relationships with physical materials. So, a good choice of the used material is essential in the design and implementation for this type of physical systems.

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