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Testing of Radar Absorbing Paint using Zinc Oxide, Polyurethane and Polyaniline as Single Layer and Multi-layered Structured-A Review

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ABSTRACT

This review is essentially based on the results of microwave absorbing paint which are increasing in demand due to their unique absorbing microwave energy and promising applications in the stealth technology of aircraft,ships, and tanks and to cover the walls of anechoic chambers. Extensive study has been carried out to develop new microwave absorbing paint with a high magnetic and electric loss. Electromagnetic are specifically chosen or designed materials such as dielectrics can inhibit the reflection or transmission of EM radiation. Various parameters such as particular absorption frequencies, thickness, component arrangement and configuration of the paint determine the capabilities and uses of these paint. In this review the effect of single and multilayer types of paint as well as effect of variation in thickness on microwave absorption properties is examined an concluded at frequency range 8 to 12 G_{HZ}

Keywords: **Microwave *absorbing material, Microwave absorbing paint, Layers, Thickness.***

I. INTRODUCTION

Nowadays intrinsic conducting polymer (ICP) continue attract much interesting in world research due to offer a great technological and commercial application potential such as static films for transparent packaging of electronic components, rechargeable batteries, light emitting diodes, protection against corrosion, conducting paints and others. A well–known specialapplication of ICP is radar absorbing materials.

The research and development of RAM have attracted considerable interesting in last few years due to the importance in world community aiming to eliminate or reduce spurious electromagnetic radiation present at environment, caused as consequence of technological advances in telecommunication area and the proliferation of a wide variety artifacts that employing high frequencies[2].

Electromagnetic radiation absorbing material or radar absorbing material(RAMs) have been the focus of much research due to increasing government regulation to control the level of EM radiation emitted by electronic equipment and also to new norms and standards issued regarding compatibility and EM interference produced by this type of equipment. RAMs are also important tools in electronic warfare, since they can be used to camouflage potential targets from radar detection. Microwave absorbers have been widely used to prevent or minimize EM reflections from large structures such as aircraft, ships,tanksand to cover the walls of anechoic chambers. RAM can be produced in different forms such as paints, sheets and thin films. Usually, these materials are obtained by the dispersion of one or more type of absorbing fillers in a polymeric matrix, which is then applied on to a substrate. Understanding the methods to produce RAMs by combining components, additives and polymeric matrices is decisive on final application of resulting material. Depending on the electromagnetic properties, the material can be either used as absorber or a reflector of EM radiations. The need of RAMs as paints has increased as a result of new civilian and military applications found for these materials. The use of materials with specific characteristics and new processes enable developing RAMs with specific physical properties, resultingin a paints that respond differently to electromagnetic radiation. Materials used as RAMs have dielectric and magnetic losses and the dependence of these losses on frequency is responsible for their performance, resulting in the absorption or scattering of EM waves. An ideal absorber might comprise a layer of materials with numerically equal values of complex permeability and permittivity and high loss tangents over a wide range of frequencies [5]. The primary mechanism of for reducing radar cross section with RAM paints is the use of lossy materials that dissipates the incident EM energy in the RAM. Two major technical challenges associated with the design of RAM materials are:

1). Matching the RAM surface impedance to that of free space thus minimizing surface back scattering.

2). Dissipating the EM signal energy within the RAM with a minimal amount of external EM energy leakage. In materials where the conduction current density is very low, the values relative permittivity and permeability must be approximately equal to achieve free space impedance matching at the surface.

When determining the performance of RAM, the most common variables used are thickness, effective frequency range and angle of incidence.[1]

Absorber theory: Microwave absorbers have been widely used to prevent or minimize electromagnetic reflections from large structures such as aircraft, ships, and tanks and to cover the walls of anechoic chambers.RAMs can be produced in different forms such as paints, sheets, and thin films.

Usually, these materials are obtained by the dispersion of one or more types of absorbing fillers in a polymeric matrix, which is then applied onto a substrate. Understanding the methods to produce RAMs by combining components, additives and polymeric matrices is decisive on the final application of the resulting material. Depending on the electromagnetic properties, the material can be either used as an absorber or a reflector of electromagnetic radiation.The need for RAMsas paints has increased as a result of the new civilian and military applications found for these materials. The use of materials with specific characteristics and new processes enable developing RAMs with special physical properties, resulting in paints that respond differently to electromagnetic radiation.

Materials used as RAMs have dielectric and magnetic losses, and the dependence of these losses on frequency is responsible for their performance, resulting in the absorption and/or scattering of electromagnetic waves. An ideal absorber might comprise a layer of material with numerically equal values of complex permeability and permittivity and high loss tangents over a wide range of frequencies. The former ensures a perfect impedance match with air, thus enabling incident signals to enter the material without front-face reflection, and the latter promotes rapid attenuation afterwards.. In dielectric materials, such as polyaniline, the complex permittivity of a material is related to its dielectric conductive properties.

Electric permittivity (ε) and magnetic permeability (μ) are parameters related to a material's dielectric and magnetic properties; they are among the most important characteristics of absorbing materials, and are directly associated with their absorbing properties. Relative permittivity and permeability are represented by Equations 1 and 2, respectively; the values of these parameters are obtained from the experimental values of the transmission and reflection coefficients of the material.

$\varepsilon_r = \varepsilon' - i\varepsilon''$ eq.(1)

$\mu_r = \mu' - i\mu''$ eq.(2)

When the material is lossy, some of the incident electromagnetic energy is dissipated, its permittivity and permeability are complex: Equations 1 and 2show the real (ε', μ') and imaginary components (ε'', μ'').The permittivity is a measure of the material's effect on the electric field in the electromagnetic waveand the permeability is a measure of the material's effect on the magnetic component of the wave. The quantity ε' is sometimes called the dielectric constant which is something of a misnomer when applied to absorbers as ε' can vary significantly with frequency. The quantity ε" is a measure of theattenuation of the electric field cause by the material.The electric loss tangent of a materialis defined as

$\tan\delta_\varepsilon = \frac{\varepsilon''}{\varepsilon'}$ eq.(3)

The greater the loss tangent of the material, the greater the attenuation as the wave travel through the material. Analogous to the electric permittivity is the magnetic permeability which is written as :

$\mu^* = \mu' - j\mu''$ eq.(4)

The permeability is a measure of the material's effect on the magnetic field. Both components contribute to wavelength compression inside the material.

In most absorbers, both permittivity and permeability are functions of frequency and can vary significantly over even a small frequency range. If the complex permittivity and permeability are known over a frequency range then the material's effect on the wave is completely known.

L.C. Folgueras et al [3] produced RAM'$_S$ in term of single and multi-layer light weight thin flexible sheets containing the conducting polymer polyaniline dispersed in a polyurethane matrix. The sheet consisted of 1 to 4 layers of absorbing materials, each having the same electromagnetic properties. EM properties of these RAMs were analysed using the waveguide technique in the frequency range of 8 to 12 G$_{HZ}$. Conducting polyaniline was prepared and obtained as a powder. The polyaniline powder was mixed with polyurethane at the proportion of 15% w/w. The attenuation of incident radiation by the RAM was obtained from the difference between the reflectivity of an aluminium plate and same aluminium plate coated with RAM. The prepared mixture of polyaniline and polyurethane was applied to a substrate as layers. Therefore the measured values of permittivity and permeability refer to 1, 2, 3 and 4 layer materials; the thickness of these layers were 2.2, 2.6, 2.8 and 3.2 mm respectively.

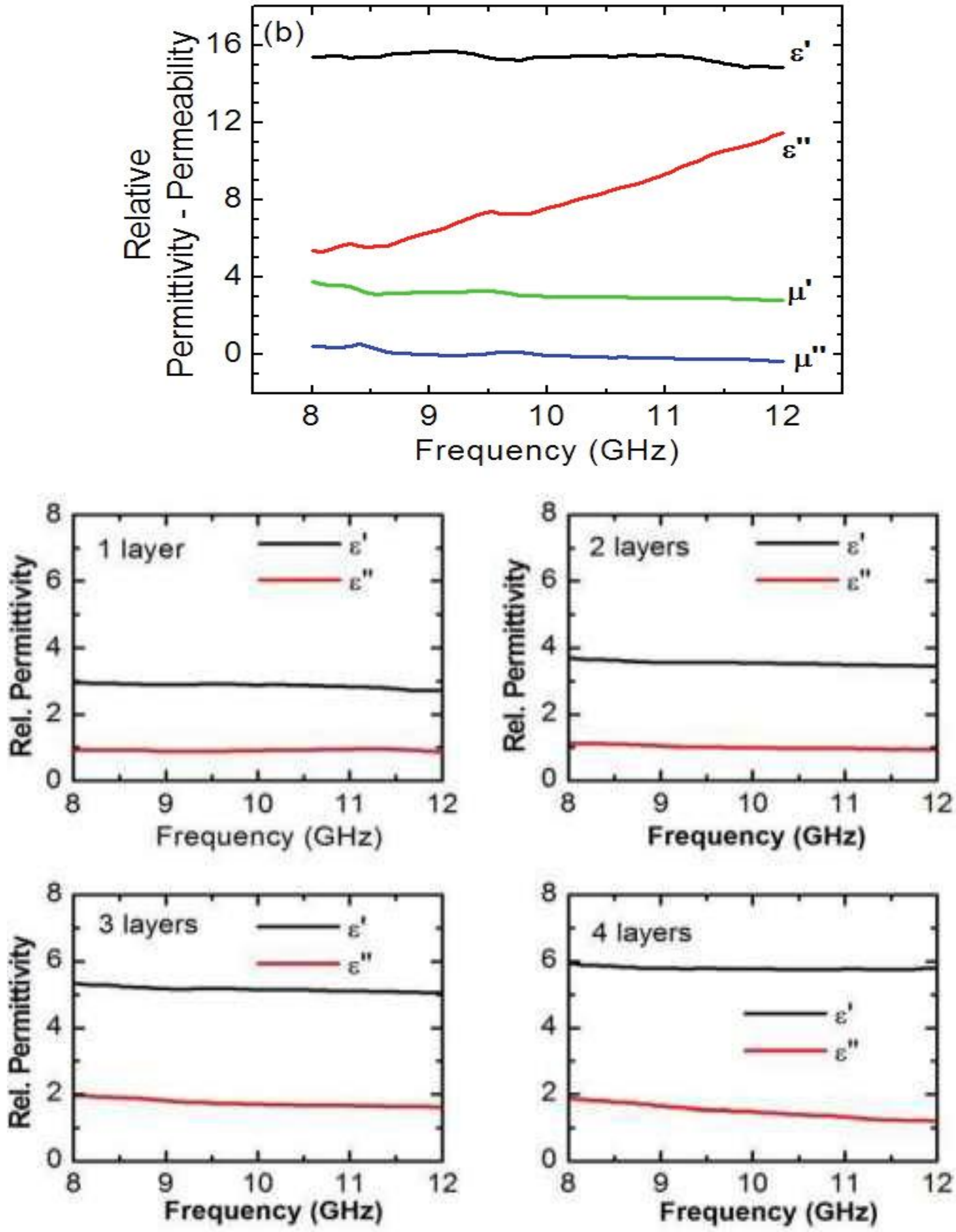

Figure 1: Relative permittivity of layered materials [3]

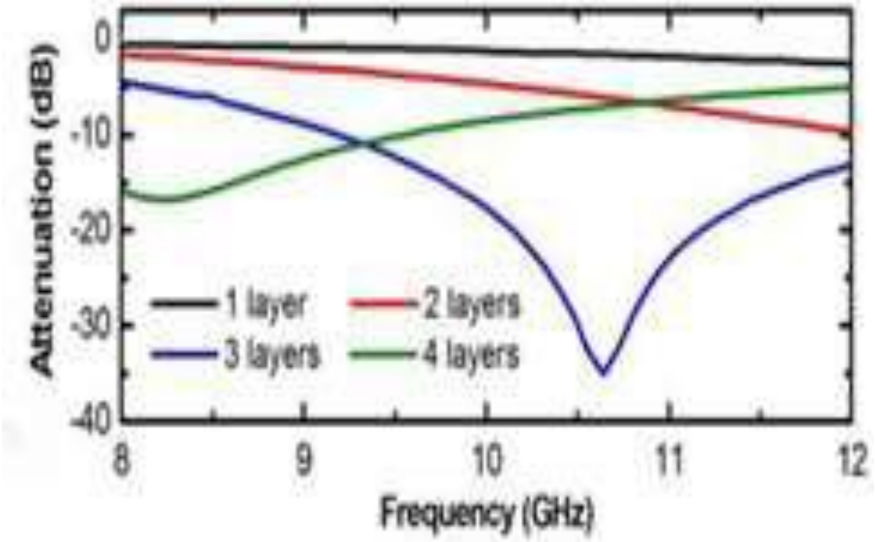

Figure 2: attenuation of the electromagnetic radiation by the layered RAM_S[3]

Figure 2 shows, that the material consisting of 3 layers, presented good absorption characteristics about 10.6 GH_Z. The resonance peaks of the other RAM_S consisting of 1 and 2 layers are outside the range of frequencies studied. The 4 layer RAM has a weaker resonance peak at about 8.2 GH_Z

Luzia de Castro Folgueras et al [5] produced sheets of microwave absorbing materials using conductive polyaniline dispersed in a silicon rubber matrix and to characterize the electromagnetic properties like absorption, transmission and reflection of electromagnetic energy and electric permittivity and magnetic permeability of these sheets in the x-band (8-12 GH_Z). Variation of the thickness and no. layers leads to alteration of electromagnetic properties of RAM_S. Small samples were cut from the sheets and inserted into waveguide. The complex electromagnetic parameters were obtained from the measured values of the S-parameters using commercial software specifically designed for this task. The attenuation of the incident radiation by the RAM_S was obtained from the difference between the reflectivity of an aluminium plate and that of the same aluminium plate covered with the RAM.

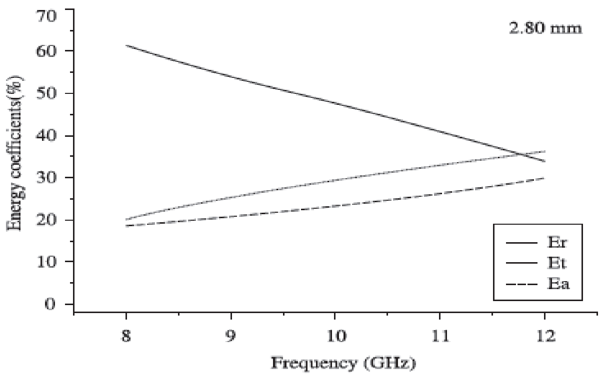

Figure 3: curve of coefficients absorbed (E_a), transmitted (E_t) and reflected (E_r) energies. RAM Thickness, 2.80 mm silicone matrix[5]

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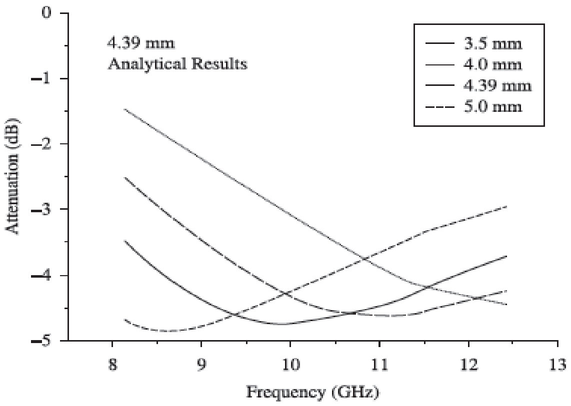

Figure 4: Energy absorptionof single-layer RAM$_S$ as a function of frequency and different layers of thickness: RAM produced with silicone rubber [5].

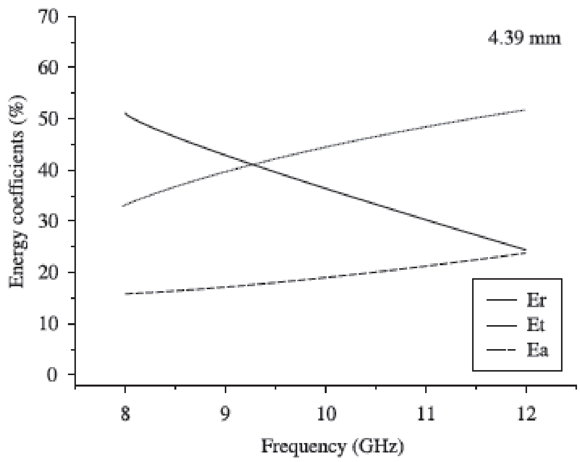

Figure 5: Curve of coefficient absorbed (E_a), transmitted (E_t) and reflected (E_r) energies: RAM thickness, 4.39mm, silicone matrix{5}

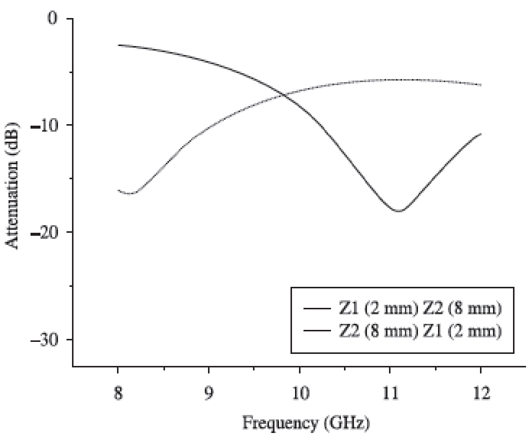

Figure 7

Table 1: Observation from Error's Reference source not found. Figure 3 and 5

S. NO.	Substrate	Thickness (mm)	Max. Energy Absorption (%)
1	Metal Plate	2.80	18.5

2	Metal plate	4.39	16.2
3	Aluminium Plate	2.80	88
4	Aluminium Plate	4.93	71

Byron T. Caudle, George T. Flowers [1] observed that in that in his study Paints containing Zinc-oxide tetrapod Whisker have been reported as having a wider bandwidth than carbon based RAM paints. Conducting polymers, such as polyaniline, have also shown significant promise as RAM paint. Polyaniline will also blend with other polymers in order to regulate resistivity and improves physical durability. Certain types of CNTs have been shown to achieve a given resistivity level at less than 1/50th the particle density by weight when compared to carbon black particle.

R. S. Biscaro, E. L. Nohara [2] has been observed that in paint formulation mixing of PU (polyurethane) gives good absorption when this paint apply on aluminium plate of thickness1 to 2 mm.

II. CONCLUSION

From the study of various papers it has been concluded that the absorption of microwave material increases with the increasing the no. of layers. This means the absorption varies from layer to layer and it also been concluded that from the study polyurethane and Zinc-oxide gives better absorption and polyaniline gives absorption as well as strength to the paint in temperature difference conditions because of its properties.It concluded that radar absorbing paint and a study of Zinc-oxide as a potential radar absorbing material

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