Different Ways For Microwave Attenuation and Associated Factors

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***Abstract*—Electromagnetic pollution is at its peak these days. People are busy finding different techniques to ease this pollution. Different techniques to determine microwave attenuation has been presented in this paper. We have also put forth the essential parameters like dielectric and magnetic loss that cultivates distinguished absorption characteristics in the microwave absorber.**

Keywords—Microwave Attenuation, Reflection Loss Dielectric Loss Tangent, Magnetic Loss Tangent

Past few years, electromagnetic pollution has captivated interest of our researchers, since it has made our biological appliances, Information technology, commercial devices, defense security vulnerable, unsafe and prone to theft. Equivalently, no private data or defense data is safe anywhere at the present minute. There is an endless fear of theft of this secured data, as a virtue of this electromagnetic pollution. This pollution can be recognized as unwelcome and troublesome aftermath of current implementation of science that has terrible consequences on human health. Not only does it adversely affect human health but also worsens the persistence and performance of modern electronic devices. Consequently, the present class of pollution has taken a form of major worriment worldwide. To deal with the same, various absorbing composites are researched.

To be an ideal microwave absorber, it should be highly stable, must possess high curie temperature i.e. temperature at which it loses its magnetic properties should be high, means it can sustain high temperatures without having affect its magnetic properties. It should also have low density, light weight, wide bandwidth of absorption, good values of saturation magnetization and very importantly should be cost economic.

Popularly ferrites with some matrices like epoxy resin, paraffin wax, aerogel, PANI are used to make absorbing composites. As an element of absorbing composite, ferrites have magnetic permeability and electrical resistivity comparably on its higher side. [1-3]. Whereas, its resistance to magnetic material and changes in magnetization at large frequencies continues its existence in the same field [4-6]. Nevertheless, being absorbing element in the composite has a drawback, possessing high density, which is unacceptable as an ideal absorber. In order to possess lower density, ferrite is fashioned in its powder mode which enhances its absorption characteristics and curtails its specific gravity [7-8]. Despite of the fact that PANI is conductive, it has gain dominance over microware absorption characteristics, however possess no property in which energy is dissipated when magnetic field is active alternately. So is not able to accomplish powerful absorption and extensive bandwidth obligation [9-10]. Amongst all, ferrites are considered to be fitting in “Good Absorber” – Category.

Microwave absorbers are exclusive material drafted to attempt the curtailment of undesirable electromagnetic energy. This energy is measured in terms of microwave attenuation. There are different techniques to measure this attenuation, which depends on various factors such as permeability, permittivity, reflection loss, dielectric and magnetic loss etc. It has been found from recent studies that customizing the shape of filler and changing it from globular to flaky, the real part of permeability is improved to greater extent, improving the absorption [11].

Following are certain techniques used to deal with attenuation in microwave frequencies

1.1 Reflection Loss Calculation

Reflection loss occurs when some of the energy is returned to the source due to “Impedance mismatch” this is also termed as -Transmission line theory [12]. From RL we can conclude on to attenuation. To further inspect the attenuation as a characteristic, reflection loss has to be calculated which is given by

Reflection loss,

$$\text{RL in dB} = 20 \log \left| \frac{(Zin-1)}{(Zin+1)} \right| \quad (1)$$

Where

$$Z_{in} = \sqrt{\mu r/\epsilon r}\ \tanh\left[j\ \frac{(2\pi f t)}{c} \sqrt{\mu r/\epsilon r}\ \right] \quad (2)$$

Also,

$$Z_{in} = \frac{impedance\ of\ composite}{impedance\ of\ air}$$

μ_r defines complex permeability, ϵ_r Complex permittivity, f stands for frequency of electromagnetic wave by which it arrives and t for thickness of absorber, c velocity of light.

Based on these equation RL is calculated which comes out to be in dB. When RL ~ -10 dB, gives 90% of attenuation and when its -20 dB, gives approximately 99% of attenuation.

1.2 By the Means of S- Parameters :

S-Parameters are scattering parameters, established to characterize the affair between different ports of a network. S parameters are often determined by the use of Vector Network Analyzer (VNA). This measuring equipment determines S parameters for a given frequency range and has a capacity to isolate transmitted as well as reflected signals by the use of director couplers [13].

In any 2 port network we have S_{11}, S_{12}, S_{21}, S_{22} as S parameters.

Here we have 2 terms namely reflection coefficient and transmission coefficient. Reflection coefficient is all about power returned to port 1 i.e. S_{11} and if it is port 2 then S_{22} (Power reflecting back from same port where

$$|S_{11}|^2 = R_1 = |P_{R1}/P_{I1}| \quad (3)$$

$$|S_{22}|^2 = R_2 = |P_{R2}/P_{22}| \quad (4)$$

Similarly, for transmission coefficient, it is total signal sent from port 1 to port 2 i.e. S_{21} and for S_{12}, vice versa.

$$|S_{12}|^2 = T_1 = |P_{T1}/P_{I1}| \quad (5)$$

$$|S_{21}|^2 = T_2 = |P_{T2}/P_{I2}| \quad (6)$$

Now, the proportion of absorbed signal P_{AS} to incident signal P_{IS}.

$$P_{AS} / P_{IS} = 1- [|S_{11}|^2 + |S_{12}|^2] \quad (7)$$

If,

$$S_R = 10 \log_{10} (1 - |S_{11}|^2) \text{ [dB]} \quad (8)$$

$$S_A = 10 \log_{10} (|S_{21}| /1 - |S_{11}|) \text{ [dB]} \quad (9)$$

then

Total shielding is given by

$$S_{Total} = S_{Absorebd} + S_{Refelcted}$$

2. Factors Contributing Attenuation

2.1 Magnetic loss Tangent

Here, tan d_m is the ratio of imaginary/real parts of permeability. Smaller is the difference between loss tangents, better is the impedance match [14]. The magnetic loss comprises of eddy current, hysteresis and residual losses given by

$$\tan d_m = \frac{\mu''}{\mu'}$$

Also, $\tan d_m = \tan d_E + \tan d_H + \tan d_R$

Eddy current loss is given by

$Loss_{eddy\ current} = V^2/R$ clearly shows up that this loss increases in decreasing resistivity of elements use in composite. Hence a ferrite with high resistivity can help in minimization of this loss.

Another loss i.e. Hysteresis loss, is evaluated by immutable wall displacement, when Hc of material is proportionally low, the hysteresis loss can be ignored [15].

The residual loss is directly linked with μ″ factor which is imaginary part of permeability.

2.2 Dielectric Loss Tangent

It is a ratio of imaginary/real parts of permittivity.

The dielectric act of ferrite depends on e^- transactions. Now if the population of charge carrier is boosted up, leads to improvement of electrical conduction phenomena and also dielectric loss is appreciated. Furthermore, the parameters like porosity, grain size etc. influence the mechanism of conduction in soft ferrites.

Discussions

1. Microwave attenuation can be determined, once the RL is calculated.

2. S-parameters are equally important in determination of microwave absorption.

3. Smaller difference between magnetic and dielectric loss tangents leads to better impedance match and hence absorption can be intensified.

4. Certain factors like porosity influence the mechanism of conduction and improve dielectric loss.

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