CHARACTERIZATION OF HEXAGONAL FERRITE BASED RADAR ABSORBER AT Ku BAND

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ABSTRACT

This paper presents the design, development and characterization of the hexagonal ferrite powder \(\text{[Ba(MnTi)}_{\delta}\text{Fe}_{(12-2\delta)}\text{O}_{19}]\) at \(\delta=1.9\) as radar absorber. The hexagonal ferrite powder has been developed by dry attrition and sintering procedure. The developed ferrite powder 60\% by weight has been mixed in epoxy resin to form a microwave absorbing paint. This paint was coated on conducting aluminum sheet to study absorption characteristics of linearly polarized TE wave at ku band. The results for single layer microwave absorber for different coating thicknesses and different particle size of ferrite power have been reported. It has been found that maximum absorption is obtained if particle size of the ferrite powder is lies in the range of 4 to 6 micron. It shows the broadband characteristics with minimum absorption of 6.5 dB from 12.8 to 16.4 GHz for a coating thickness of 2 mm and particle size of 4 micron. These paints are very useful in military application such as RCS reduction, camouflage of the target and prevention of EMI etc.

Key Words: Hexagonal Ferrite, Radar Cross Section, Microwave Absorbing Paint, EMC

1. INTRODUCTION:

The reduction of electromagnetic backscatter with the use of radar absorbing material (RAM) has important implication in the field of radar and electromagnetic compatibility. A typical RAM usually consist of a thin lossy coating of dielectric or magnetic material over the surface of prefect electric conductor (PEC). These RAM have a particular depth of coating and as such are inherently narrow band. Currently in this field there is interest in the use of Hexagonal Ferrite based microwave absorber to act as a RAM and provide absorption over a wide bandwidth \([1][2]\).

Ferrite is an very important class of magnetic material, more especially it is a metal oxide, which contain magnetic ions arranged in such a manner, which produces spontaneous magnetization, while maintains good
dielectric properties. The hexagonal type ferrite absorb microwave energy by lossy interaction of the magnetic field of the wave with their individual magnetization. The hexagonal ferrite materials are suitable RAM due to significant value of permeability (>1), high value of magnetization and planar anisotropic behavior in microwave frequencies.[3] [4]

There are several types of hexagonal ferrite denoted as M,W and Y phase having complex crystal and magnetic structure. The magnetic ions can be removed by substituting divalent ion and the magnetization was reported to be increased with increasing amount of non-magnetic substitution. The presence of large barium ions and the slightly modified crystal structure causes the barium hexaferrite to have high magnetic properties unlike spinel and garnets. The magnetization and the anisotropy of Barium Hexagonal ferrite can be further improved by the external doping of divalent ions(Zn,Co, Ni etc.).[4]

In the present communication the microwave absorption characteristics of manganese and Titanium substituted barium hexagonal ferrite paint of single layer coating for different thickness and particle size have been presented.

2. Preparation of Ferrite and Its Characterization [2]

The samples of hexagonal ferrite powder with different particle size of ferrite composition [Ba(MnTi)\(\delta\)Fe\(\beta\)\(12-2\delta\)O\(19\)] at \(\delta=1.9\) were prepared by dry attrition and sintering process. The starting material were BaCO\(_3\), MnCO\(_3\),TiO\(_2\), CoCO\(_3\) and Fe\(_2\)O\(_3\). The sintering was carried out at 1150 °C for 8 hours. Four sample of ferrite powder with different particle size 4 micron,6 micron ,8 micron and 12 micron were prepared by controlling the time of milling. The developed ferrite powder 60% by weight mixed in 40% part of an epoxy resin(mat sole) to form a microwave absorbing paint. The developed microwave absorbing paint have been coated on the aluminum conducting sheet.

3. Measurement of Microwave Absorption

The Experimental set up for measurement of microwave absorption at X band as shown in fig.1.The microwave absorption has been measured by ATD method[2] [5] ATD (Absorber Testing Device) is basically a pyramidal horn antenna with extended wave-guide section is connected at the aperture of the horn
antenna. A reflected power in power meter noted with aluminum plate. And reflected power with absorber plate noted in power meter. The difference in two reading gives the power absorbed by the absorber power. [2] [7]

Microwave Source (1) Isolator (2) 3 dB directional coupler (3) Power meter (4) Absorber Testing Device (5) Fig1. Experimental Set up for measurement of microwave absorption

4. RESULTS & DISCUSSION

The effect of particle size on microwave absorption characteristics are shown from fig.2 to fig.5 for different coating thicknesses.

Fig.2 represent the microwave absorption characteristics for hexagonal ferrite based paints for different particle size at coating thickness of t=0.75 mm. From figure it is found that the absorption is depends on the particle size of the ferrite powder. The peak absorption is obtained at 13.8 GHz with values of 9.7 dB, 6.8 dB, 5.9 dB and 4.7 dB for particle size of 4, 6, 8, 12 microns respectively. It is also found that it provide minimum absorption of 6.2 dB from 12.8 to 14 GHz.

Fig.3 shows the effect of particle size on the absorption characteristics of hexagonal ferrite based paint of coating thickness t=2 mm, from figure it is observed that the maximum microwave absorption of 12 dB is obtained at 13.6 GHz. It also provide the minimum absorption of 8.1 dB from 12.8 to 14 GHz for the particle size of particle is lies in the range of 4 microns.

5. CONCLUSION

In this paper authors have discussed the effect of particle size on the performance characteristics of single layer microwave absorber using M type hexagonal ferrite materials. In the present investigation it is concluded that the peak value of absorption depends on coating thickness and particle size of the ferrite powder. The broadband characteristics of absorption is obtained between the frequency range of 12.8 GHz to 16.4 GHz with a minimum absorption of 6.5 dB at coating thickness of paint t=2 mm. Hence because of broad band nature of absorber, this can be used for reduction of radar cross section of the military air craft.
REFERENCES


FIG 2 EFFECT OF PARTICLE SIZE ON MICROWAVE ABSORPTION OF FERRITE BASED PAINT AT
COATING THICKNESS (t=0.75mm)

FIG 3. EFFECT OF PARTICLE SIZE ON MICROWAVE ABSORPTION
OF FERRITE BASED PAINT FOR COATING THICKNESS (t=2 mm)