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CHARACTERIZATION AT MICROWAVE FREQUENCIES OF MAGNETIC COMPOSITE AND SHIELDS FOR ELECTROMAGNETIC PROTECTION

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Rapid developments in telecommunications and digital processing of information are facing the problem of electromagnetic wave pollution and interference. The aim of this article is the characterization at microwave frequencies [2] of new magnetic composite materials [1], for broadband electromagnetic wave shields. We report the preparation and microwave properties of new magnetic composite materials and electromagnetic shields. These materials contain a ferromagnetic composite, in proportion of 60-99%. The magnetic properties at microwave frequencies have been determined between 0.8-12 GHz. The properties of attenuation at microwave frequencies have been correlated with the composition of ferromagnetic composites.

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1. Introduction

Recently, as the number of systems using high frequency electromagnetic waves has increased, serious electromagnetic compatibility (EMC) problems have become apparent [3].

A series of studies has been conducted into possible health effects of exposure to no ionizing electromagnetic field. Unionizing electromagnetic fields are produced by devices involved in the generation, distribution or use electromagnetic waves. On the other hand insufficient research has been conducted to protect the people of non-ionizing electromagnetic fields produced by mobile telephones, telecommunication transmitter, microwave ovens, radars, diathermy units etc. Carbonyl iron loaded rubber is often used to achieve the absorbers, which has, however, narrowed bandwidth. The bandwidth Ba M-type ferrites are still too small(<1 GHz) and need to be expanded.

The aim of this study is the research of new magnetic composite material for broadband electromagnetic wave absorbers and shields and the characterization of shields at microwave frequencies, 0.8-12 GHz.

2. Experimental procedure

The magnetic composites have been obtained by processing of the chemical offal from Chemical Industry [1].

By heat treatment in air or reducing atmosphere take place the phase transformation of Fe_2O_3 into Fe_3O_4, γ Fe_2O_3 and Fe metallic. X-ray diffraction and scanning electron microscopy were used to find detailed information on the crystallography and morphology of magnetite and iron formation as a function of processing technology. A correlation was established between magnetic hysteresis parameters and the observed crystal structure evolution. The samples of pyrites ashes

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calcined in reducing atmosphere show the best magnetic properties, the specific magnetization of 128 emu/g.

The magnetic composite and shields have been obtained by mixing the ferrite, grade MZ8, with pyrites ashes 50%, to see below experimental results for samples 1and 2.

The magnetic composite, based pyrites ashes, was compacted with a powdered epoxy-acrylic resin composition, at a ratio of 1-3 mass %. Another set of samples was obtained by mixing pyrites ashes with the rubber (at a ratio of 40-60 mass %).

The properties of attenuation at microwave frequencies have been determined between 0.8-11 GHz, by the method of the transmission line, using measuring set-up RAFENA-WERKE. The analysis is based on Schekunoff impedance concept.

2.1. Experimental setup

A block diagram of the complete experimental setup is shown in Fig.1. The main component of the setup is a coaxial transmission line (RAFENA-WERKE, Type DML -112A, 0.5- 3.5GHz bandwidth, characteristic impedance Z_0 = 50Ω) equipped with a RF detector. The RF detection probe consists of a semiconductor diode which slides along the outside of the coaxial transmission line. The output dc voltage provide by RF detection probe is applied to a digital voltmeter.
The coaxial transmission line is excited by a microwave signal generator (TESLA, Type TR-0611). In order to avoid the signal generator overload the coaxial transmission line and signal generator are separated by a calibrated attenuators chain (ROHDE&SCHWARZ, Types DPF BN 18064 and RBD BN 33661, 0-4GHz bandwidth). The coaxial transmission line is terminated with a home-made test holder. The test holder is composed of two concentric conductors separated by an empty space. The inner diameter of the outer conductor and the outer diameter of the inner conductor are D=24 mm and d=14 mm, respectively. The calculated characteristic impedance of the test holder is found to be Z_M = 32 Ω. The sample outer and inner diameters are 23.5 and 14 mm, respectively. One of the test holder extremities is connected to the coaxial transmission line while the other can be connected to a Z_z = 50 Ω calibrated load or can be terminated with a transverse sheet of metal Z_z = 0.

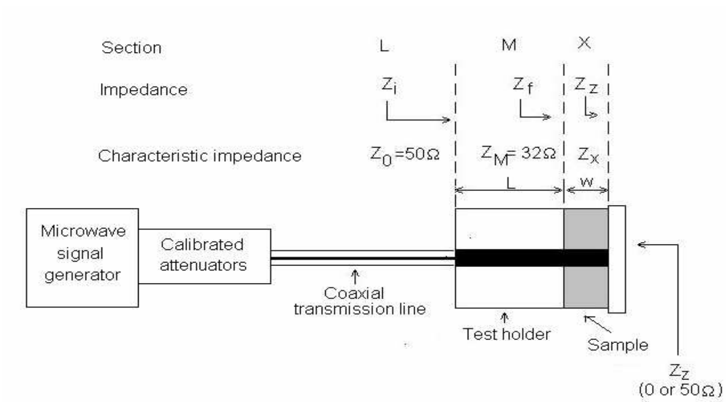

Fig. 1 Experimental setup. Block diagram.

2.2 Theory

The characteristic impedance Z_C and propagation constant γ of a transmission line are given by:

$$Z_C = \sqrt{\frac{R_L + j\omega L_L}{G_L + j\omega C_L}} \tag{1}$$

and

$$\gamma = \alpha + \beta j = \sqrt{(R_L + j\omega L_L)(G_L + j\omega C_L)} \tag{2}$$

where $R_L + j\omega L_L$ is the complex series impedance per unit length of transmission line and $G_L + j\omega C_L$ is the complex shunt admittance. The measurement a load impedance is well known [2] and it will be not described here. The input impedance Z_f and Z_X can be expressed as a function of measured impedances Z_i. The input impedance Z_i of a transmission line terminated in a load impedance Z_S is given by [2]:

Z_C is the characteristic impedance of the transmission line.

$$Z_i = Z_C \frac{Z_S + Z_C th(\gamma \ell)}{Z_C + Z_S th(\gamma \ell)} \tag{3}$$

If in Eq (3), th(γw) is substituted with Z_{f0}/Z_X, results :

$$\frac{1}{Z_X^2} = A + jB = \frac{Z_Z + Z_{f0} - Z_f}{Z_Z Z_{f0} Z_f} \tag{4}$$

If Z_X is known, then the following relations may be written:

$$th(\gamma w) = \frac{e^{\gamma w} - e^{-\gamma w}}{e^{\gamma w} + e^{-\gamma w}} = \frac{e^{2\gamma w} - 1}{e^{2\gamma w} + 1} = \frac{Z_{f0}}{Z_X} \text{ or } e^{2\gamma w} = \frac{Z_X + Z_{f0}}{Z_X - Z_{f0}} \tag{5}$$

$$\alpha = \frac{1}{2w} \ln \left| \frac{Z_X + Z_{f0}}{Z_X - Z_{f0}} \right| \tag{6}$$

3. Results and discussion

Relations (4) and (6) allow to calculate the parameters A, B, and α. From these, the permeability, permittivity and conductivity of the sample can be calculated. The attenuation of the RF field is described by the real part α of the propagation constant γ (attenuation constant). Fig. 2 shows the attenuation of 1-2.5 GHz for the samples compacted with epoxy-acrylic resin, calcined at different temperatures and atmosphere. Best results were obtained for the composites with 80-100% ferromagnetic materials. Table 1 shows the attenuation of shields prepared from ferrite 50% + pyrites ashes 50%. Fig. 3 shows the comparison of the attenuation for magnetic shields obtained from ferrite 50% + pyrites ashes 50% and pyrites ashes 100%mixed with epoxy-acrylic resin and rubber.

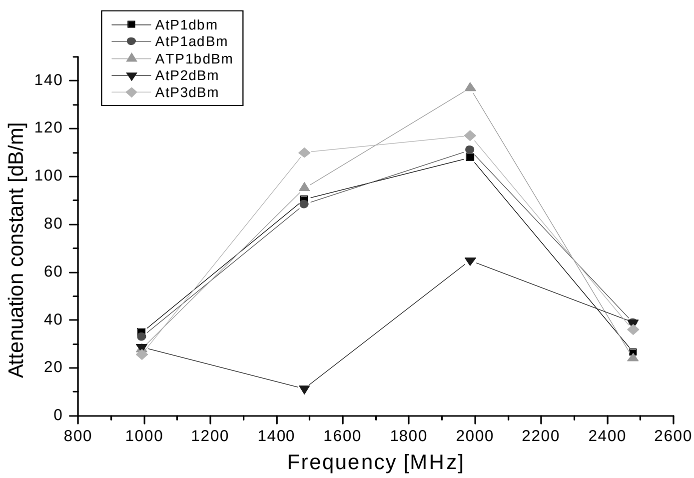

Fig. 2. Attenuation of the magnetic composites compacted with epoxy-acrylic resin.

Table 1.

Sample 1 Composite: ferrite + pyrites ashes		Sample 2 Composite: ferrite + pyrites ashes	
Frequency (MHz)	Attenuation (dB)	Frequency (MHz)	Attenuation (dB)
800	48	800	48
850	48	850	50
900	56	900	58
950	56	950	56
1 000	48	1 000	48
1 100	37	1 100	45
1 200	49	1 200	58
1 300	53	1 300	64
1 700	35	1 700	37
2 000	26	2 000	39
2 300	43	2 300	43
2 500	40	2 500	37
3 000	38	3 000	53
3 300	42	3 300	45
3 500	47	3 500	44
4 000	36	4 000	38
4 300	36	4 300	34
5 900	53	5 900	48
6 500	41	6 500	40
7 000	58	7 000	47
7 500	40	7 500	37
8 000	40	8 000	39
8 500	35	8 500	32
9 500	51	9 500	48
10 000	20	10 000	24

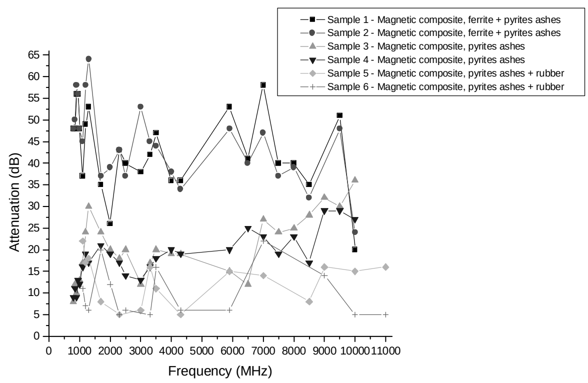

Fig. 3. Attenuation for magnetic shields obtained from ferrite 50% + pyrites ashes 50%, pyrites ashes 100% and pyrites ashes +rubber.

We conclude that the magnetic composite material obtained from ferrite 50% + pyrites ashes 50% with epoxy-acrylic resin is a good candidate for use as wide bandwidth electromagnetic microwave absorbers and shields.

References

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