Researching of ferromagnetic inclusions influence on protecting properties of shielding composite materials with dielectric and magnetic structure elements

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Abstract

The effect of ferromagnetic impurities in electromagnetic absorbers is studied. It has established that a small amount of magnetic powder in composite structure influence on attenuation and reflection characteristics of shielding material. These magnetic inclusions can increase the attenuation at 15 dB and reflection coefficient at 2,5 dB in comparison with dielectric samples. The compound with powders of silica and nickel-zinc ferrite as a base of shielding composite has investigated. The dependence of the shielding characteristics of the composite is shown. The use of these composite materials for creation of electromagnetic shielding constructions are considered.

1. Introduction

Exploitation of electromagnetic resource has resulted to development of different radio services, communications, navigation, detection systems, consumer electronics etc. Working band of radioelectronic devices and computers tends to higher frequencies, and using of pulse signals, sensitivity and density of sources are increased that arises electromagnetic compatibility and radioecology problems. Nowadays wide using of electromagnetic devises follows unsafely existing of biological living forms [1]. We may decrease negative effect from electromagnetic radiation on biological structures by applications of electromagnetic shields. The main purpose for scientists and researchers in this scientific field is to create shielding materials and constructions that have high efficiency in wide range of frequency, low cost and are suitable for any applications. Composite materials are having prospects for solve this problem [2]. It allows making shielding constructions with preset parameters, taking into account exploitation requirements. For creation of electromagnetic absorbers that provide high shielding stability in wide range of frequencies we can use different constructions and materials with dielectric, magnetic and conductive losses [3, 4].

The aim of this paper investigation is determination of electromagnetic radiation attenuation features by dielectric powder sorbent with ferromagnetic impurities and establishing of shielding properties depending on compound of composite absorption material.

2. Experiment

For the experiment samples with size 5 cm × 5 cm and thickness in 3 mm were prepared. The main part of the composite is powder silica, about 80 percent on volume. As a magnetic component, nickel-zinc ferrite was used, about 20 percent on volume. After mixing of powder components till distribution uniform of dielectric and magnetic particles over the sample, a small amount of liquid (no more than 30 percent on weight of all components) was added for creation homogeneous structure and keeping stability placing of components. For comparison, the same sample, but without powder magnetic particles was made. The samples sealing was made by polyethylene.

Measurements were carried out in frequency ranges of 8…11,5 GHz. Panoramic indicators of voltage standing wave ratio (VSWR) and attenuation and waveguide lines were used for electromagnetic energy attenuation observation. The measurement inaccuracy is not higher than 1,5 dB. Before measurement of attenuation, samples water saturation was estimated by weighing.

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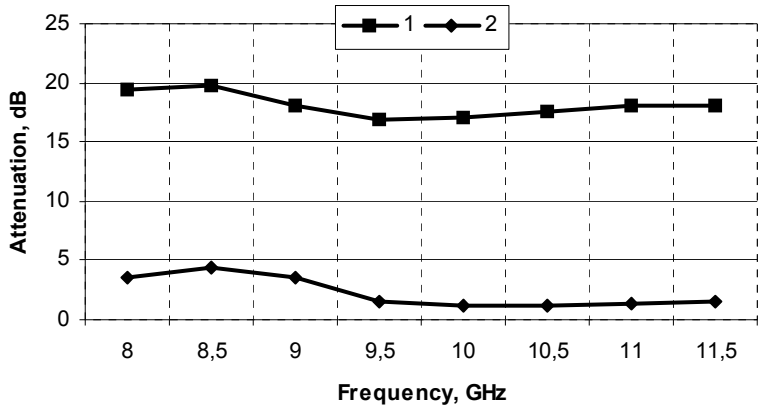
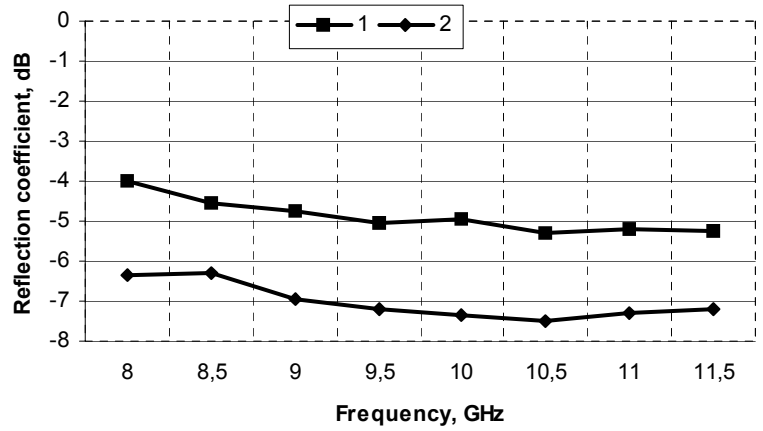
3. Results and discussion

Analysis of measured attenuation characteristics in different frequency ranges shows that ferromagnetic includes increase attenuation in researching range of frequencies at 15 dB. As it is sown on the fig. 1(a), composite materials with both dielectric and magnetic components provide electromagnetic radiation attenuation about 20 dB. Composite materials without magnetic components reduce electromagnetic radiation about 5dB. It means that ferrite particles provide magnetic losses.



a)



b)

Figure 1 – Attenuation (a) and reflection (b) of electromagnetic emission by composite materials in the frequency ranges 8…11,5 GHz: 1 – sample with magnetic inclusions; 2 – sample without magnetic inclusions.

Electromagnetic radiation (EMR) and water interaction in microwave frequency range is connected with relaxation process of water dipoles orientation polarization and is described in Debay's theory. This kind of polarization is provided dielectric losses in water-containing materials at microwaves. But we should not take into account this phenomenon for comparison because of all samples have equal moisture degree.

Composite ferromagnetic includes also increase electromagnetic waves reflection in researching range of frequencies at 2,5 dB in comparison with non-magnetic structure. As it is sown on the fig. 1(b), composite materials with both dielectric and magnetic components provide reflection coefficient about – 7 dB. Composite materials without magnetic components have reflection coefficient about –5 dB. It is can be explained by metal properties to reflect electromagnetic waves.

Observed in the magnetic fluid magnetomechanical, magneto-optical and electrical phenomena are largely determined by the properties of small magnetic particles, their interaction in the external fields and the structural state of the system. Polarization of the system, which comprises a magnetic powder, is strongly dependent on the frequency of the electromagnetic field. Magnetic and dielectric losses are due to polarization components provide attenuation of the electromagnetic field. Simulation of the system parameters can be done based on the values of the permittivity and permeability of composite components. In this frequency range, features of the experimental model are stable that allows making of comparative analysis of the samples, based on experimental data. That is why we can see almost linear dependence of the shielding characteristics from the magnetic impurities presence over the measuring frequency range. In any case, the analysis of the examined samples allows us to conclude that magnetic component addition into the composite leads to increased attenuation of electromagnetic waves.

Further developments in this researching area will be associated with the optimization of the elements combination in composite to obtain the required technical and shielding features.

5. Conclusion

The presented results show that addition of magnetic components in composite structure with dielectric powders allows increasing electromagnetic shielding efficiency due to the rise of electromagnetic radiation absorption mainly. The presence of ferrite particles in silica powder affects on electromagnetic characteristics of the material. Formation gradient multilayer structure enables to receive electromagnetic radiation absorber with the least reflection from a surface of the screen with preservation of high shielding efficiency via absorption. As it was shown, the small amount of magnetic powder components increases efficiency of composite electromagnetic absorbers for protection of biological organisms and information objects from radiation negative impact. That is why these results can be used to develop and create new types of electromagnetic shielding constructions with the required parameters.

7. References

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