Selective EHF absorber based on $BaFe_{12}O_{19}$ hexaferrite

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Abstract. The results of the study of the electromagnetic response of the hexagonal ferrite composite $BaFe_{12}O_{19}$ in the frequency range 34-250 GHz at room temperature are presented. At a frequency of 46.5 GHz a region of natural ferromagnetic resonance was found. The possibility of creating a selective EHF absorber based on the developed material is shown.

1 Introduction

Trends in modern instrumentation focused on the development of extremely high frequency range (EHF). Along with research in the field of generation and detection of EHF radiation occupies a special place the issue of electromagnetic compatibility of separate units of transceiver modules and the creation of frequency-selective elements. At frequencies below 20 GHz the frequency filtering task is successfully solved by ferrites structures Z and W [1-2]. In the UHF range ensure the effective interaction of electromagnetic radiation with matter is possible through the use of hexagonal ferrite M-type crystal structure $BaFe_{12}O_{19}$ due to the high field values magnetocrystalline anisotropy and magnetization saturation. In addition, the frequency of resonance absorption of hexaferrite affects the size and shape of the particles [3]. Thus it is of interest to explore this material in the composition mixture to provide the required absorbing characteristics combined with optimum weight and size parameters.

2 Objects of research

The production of samples took place in several stages. At first, there was a choice of matrix plastic and filler for the manufacture of composite. Then the components were mixed by chemical treatment. The matrix plastic is pre-dissolved in dimethylketone. At the next stage, ultrasonic processing of the material was carried out using the device of the «Alena» series, model UZTA-0.1 / 2.8-O, which allows for greater homogeneity. The power of ultrasound was 75 W. After this, the mixture cooled at room temperature. Solidify material was prepared for extrusion, cut into strips and passed the extrusion stage. This step should be repeated several times until a filament without defects is received. Finished filament was put in to a 3D printer with a diameter of the nozzle equal 1 mm. At the end, the samples mechanical processed for subsequent measurement in the terahertz spectrometer.

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For the research composite materials were prepared (Table 1) based on 60 wt. % BaFe12O19 ferrite and 40 wt% matrix: acrylonitrile butadiene styrene (ABS), epoxy resin, urethane-alkyd lacquer and water-based paint.

Table 1. Characteristics of the samples

Matrix	Filler	Sample Thickness	Filler Particle Size
ABS plastic	60% $BaFe_{12}O_{19}$	2.04 mm	< 100 µm
Epoxy resin		1.21 mm	90-160 µm
Urethane Alkyd Lacquer		1.30 mm	90-160 µm
Water paint		1.45 mm	< 80 µm

3 Measurement technique and experimental results

The samples in the form of round plane-parallel plate were made. The electromagnetic response from composite materials was measured by the non-contact quasi-optical method using a spectrometer based on backward wave oscillator [4]. Detection of transmitted radiation was carried out by an optoacoustic converter (Golay cell). Amplitude modulation was performed by mechanical chopper. The focus of the quasi-optical beam was made by teflon lenses. The transmission coefficient of electromagnetic radiation of the studied samples was determined as the ratio of the power of the transmitted radiation to the power of empty path.(Fig.1)

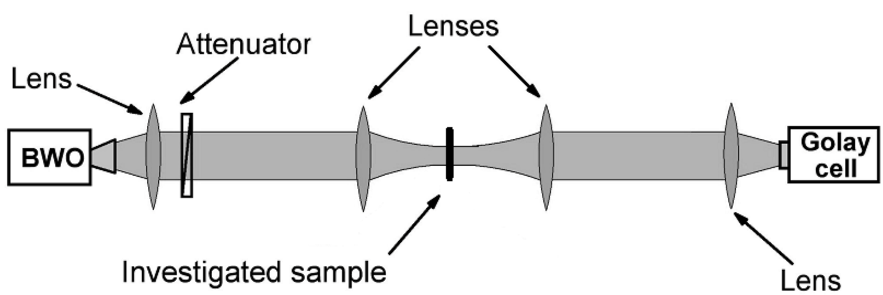

Fig. 1. Experimental setup of spectrometer for research electrophysical properties of composite materials in EHF range.

Fig. 2-5 shows the frequency dependence of the transmission coefficients for the research composites.

For all samples, a region of selective absorption of electromagnetic energy is observed, the maximum of which is located near the frequency of 50 GHz. This result can be explained by the presence of the effect of natural ferromagnetic resonance. A composite based on $BaFe_{12}O_{19}$ ferrite and water-based paint possesses the best frequency-barrier properties.

4 Conclusion

Thus, the obtained experimental data can be the basis for the creation of frequency-barrier filters of the EHF range in transceiver systems. The level of attenuation of electromagnetic radiation in the region of natural ferromagnetic resonance can be controlled over a wide range by changing the mass ratio between the active component and the matrix [6-12]. By varying the matrix in a Ba-M-based ferrite composite, it is possible to create flexible, light, thin radar absorbing coatings.

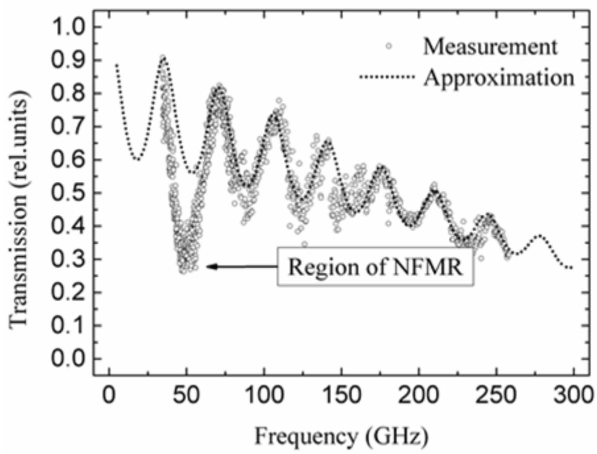

Fig. 2. Frequency dependence of the transmission coefficient of composite based on 60 wt.% $BaFe_{12}O_{19}$ ferrite and ABS plastic matrix.

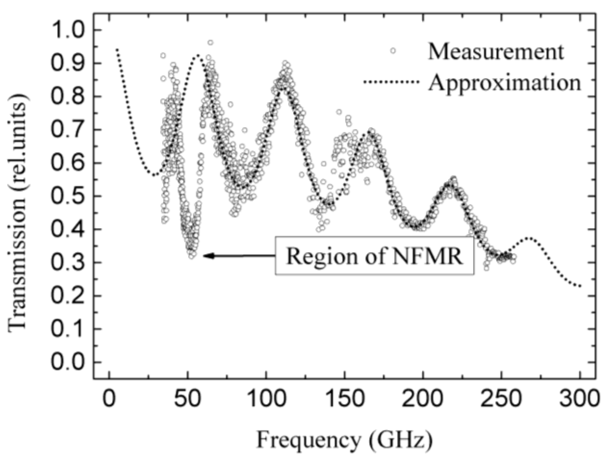

Fig. 3. Frequency dependence of the transmission coefficient of composite based on 60 wt.% $BaFe_{12}O_{19}$ ferrite and epoxy resin

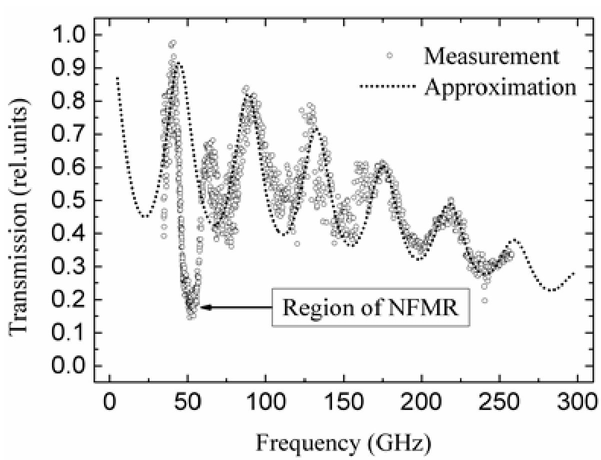

Fig. 4. Frequency dependence of the transmission coefficient of composite based on 60 wt.% $BaFe_{12}O_{19}$ ferrite and urethane-alkyd lacquer.

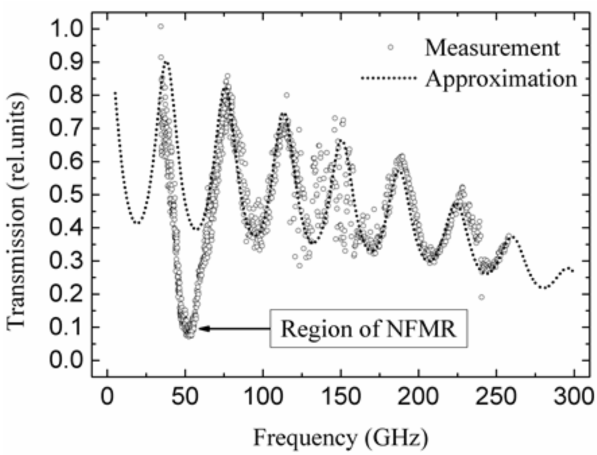

Fig. 5. Frequency dependence of the transmission coefficient of composite based on 60 wt.% $BaFe_{12}O_{19}$ ferrite and water-based paint.

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