Structural and Magnetic Characteristics of Anisotropic Composite Materials Based on Y-Type Hexagonal Ferrites

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In this work, Y-type hexaferrites $Ba_2NiCuFe_{12}O_{22}$ was selected as the filler in epoxi resin composites. Hexaferrites were prepared using standard ceramic processing. The composite samples with magnetic texture and without one were studied. The phase composition, morphology, magnetic and electromagnetic properties both fillers and composite are studied. Ferromagnetic resonance technique is applied to measure the magnetocrystalline anisotropy of synthesized hexaferrites. The spectra of the permeability and permittivity and the frequency dependences of the reflection coefficients of composite materials are studied at the microwave frequency band

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Results

X-ray phase analysis

Phase composition of $Ba_2NiCuFe_{12}O_{22}$ hexaferrites

Y-phase, %	Fe_3O_4, %	α-Fe_2O_3, %	M-phase, %	σ_S, Gs·cm^3/g
83.0	11.0	3.0	3.0	37.1

As a result of the study, it was found the Y-type hexaferrites are multi-phase.

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Magnetization curves

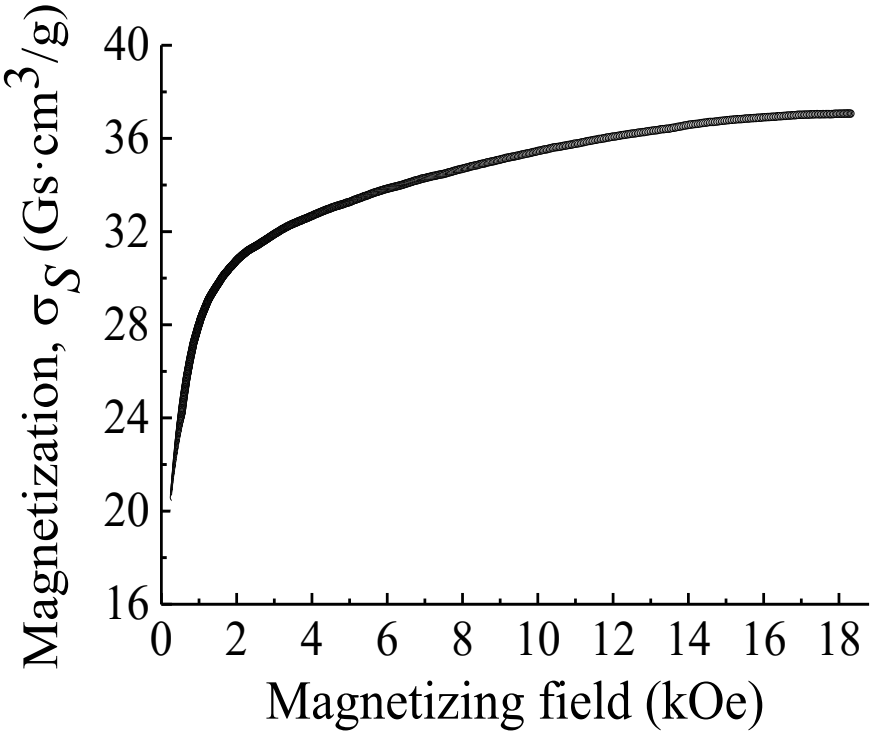

Fig 1. Magnetization curve of NiCu–Y hexaferrite powder

The obtained saturation magnetization values considerably exceed the values given in different literature sources. This distinction can be explained by the presence of impurity phases possessing a high saturation magnetization.

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FMR measurements of magnetocrystalline anisotropy

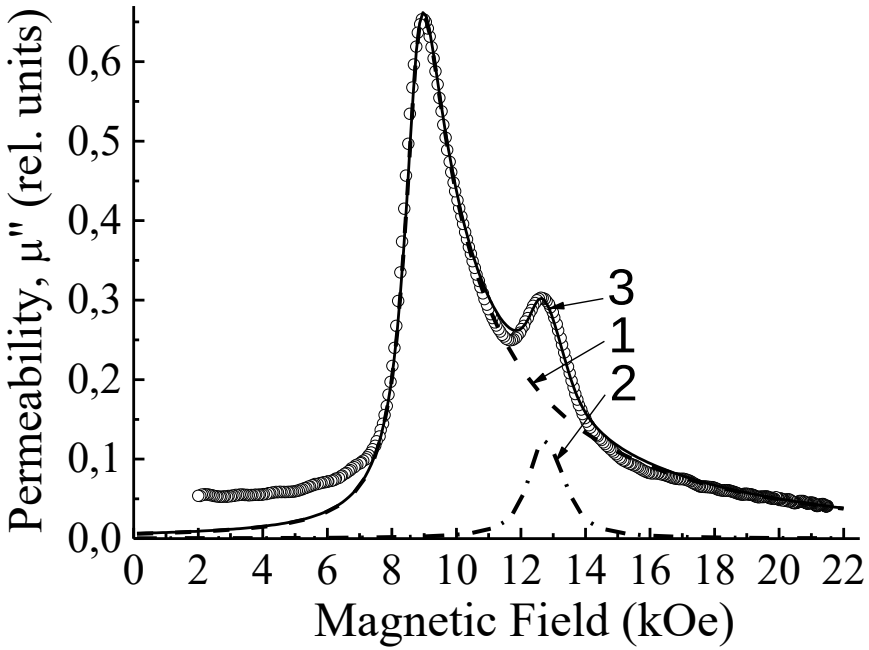

Fig 2. Experimental (circles) and theoretical (dashed and solid lines) FMR curves at 37 GHz; 1 – NiCuY phase, 2 – magnetite phase, 3 – total curve

Y-phase	
H_a, кЭ	–11.3
Fe_3O_4	
H_a, кЭ	–0.6

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Morphology of the hexaferrite-based composite surface

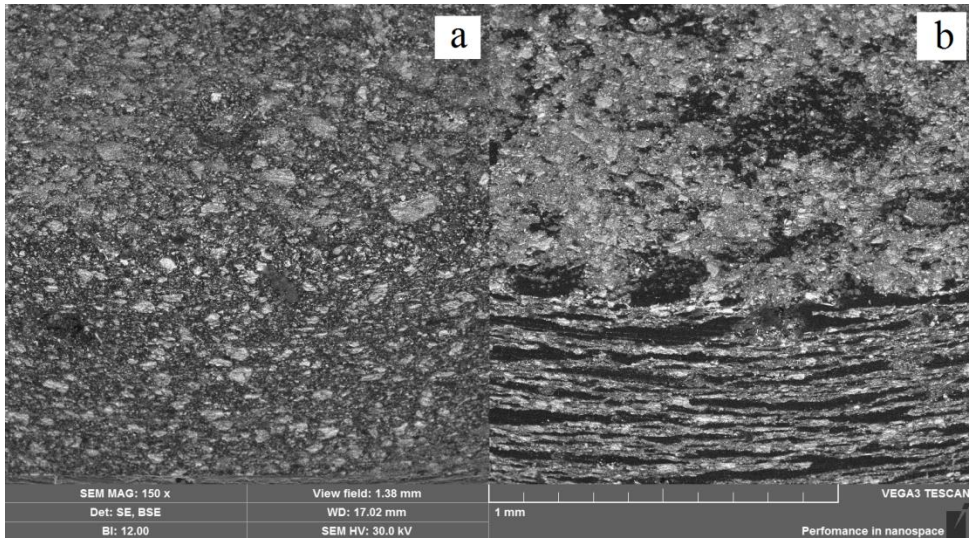

Fig.3. Surface morphology of a composite material based on Y-type hexaferrite manufactured (a) without treatment and (b) with treatment by an external magnetic field

The grey hexagonal particles representing the filling composite material have the size of 10–20 μm. Black areas corresponds to the polymer matrix. The samples have not neither pores nor other defects. It is clear that that the non-textured sample (a) is isotropic, while the textured sample (b) has a layered structure.

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Electromagnetic response of hexaferrite-based composites

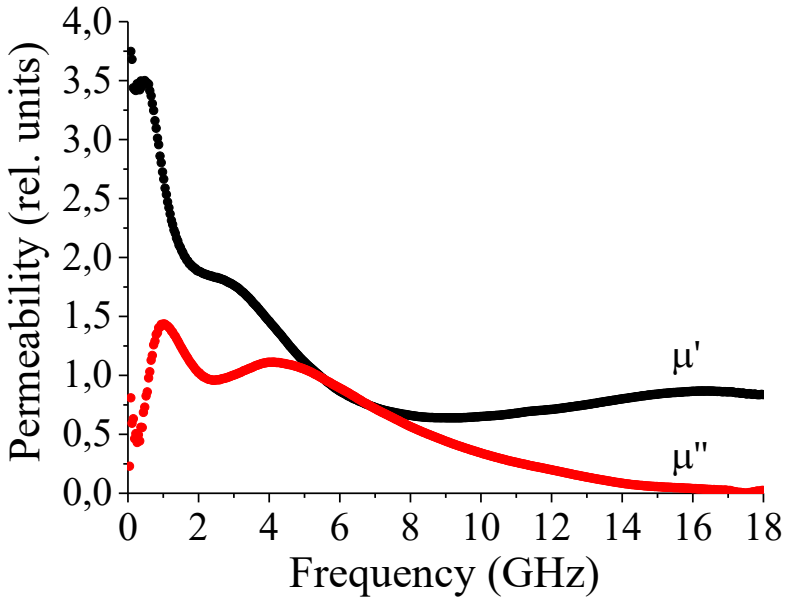

Fig. 4. Frequency dependence of permeability

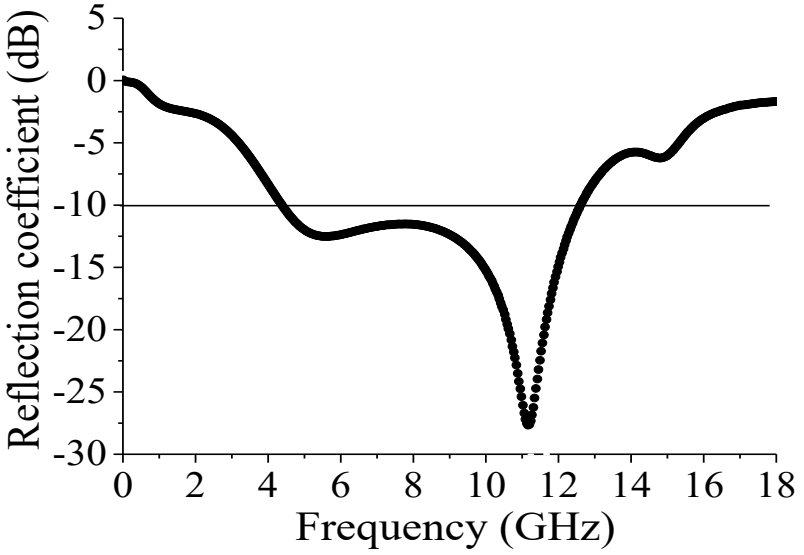

Fig. 5. Frequency dependence of reflection coefficients

Two dispersion regions are found on the imaginary part of permeability spectra. It shows the processes of displacement and resonance of the domain walls at frequency 1.2 GHz and natural ferromagnetic resonance in 4–7 GHz band. The comparison with results [4] shows that both real and imaginary magnetic permeability are increases. It is a testament to the fact that the magnetic structure of the sample has undergone changes.

The reflection coefficients are lower –10 dB which corresponds to the absorption of 90% EMR in 4.5–12.6 GHz band.

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CONCLUSION

As a result of the study, it was found the Y-type hexaferrites are multi-phase. The dependencies of the specific saturation magnetization and anisotropy fields of samples from concentration were investigated. It was determined the studied Y-type hexaferrite possessed the magnetic ordering of the EMP type.

The samples of composite materials were prepared on the basis of these hexaferrite powders. Their surface morphology, electromagnetic properties and reflection coefficients were measured. Due to low reflection coefficients of the synthesized hexaferrite-based composites of NiCu–Y system, it will allow using these composites as absorbers of microwave electromagnetic radiation.

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