Electromagnetic Characteristics of Composites Based on Nanosized Hexaferrites BaM at Microwaves

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Abstract **– Electromagnetic characteristics of composites based on nanopowders of M-type hexaferrite were investigated. Powders of hexaferrite were obtained by by SHS synthesis. Electromagnetic characteristics of synthesized materials are such as electromagnetic characteristics of obtained by ceramic technology.**

Index Terms **– hexaferrite, composites, microwaves, reflection coefficient**

I. INTRODUCTION

NEW materials are need for: development of equipment parts; providing of electromagnetic compatibility of separate parts of equipment; matching whole receive/transmit path; protection of biological objects from microwave treatment.

At the present time most perspective materials are polymer composites with powder fillers. As active phase of fillers very important materials active interacting with electromagnetic radiation.

Radioreflecting materials have high electro conductivity (iron, steel, copper, brass, aluminum and some composites). They have high efficiency caused by high differences between wave resistance of free space and material's, also these materials have high reflection coefficient. Though, at the practice there are some shortcomings [1], related with appearance areas of re-emission caused by changing of shield position relative to radiators and shielding object. This leads to appearance of re-emission waves, but power of electromagnetic radiation at different parts of space increase. That is why specific attention gives to development of materials and constructions based on them. Efficiency of them is achieved by active interaction of electromagnetic radiation with substance

At this type of materials there is transformation of electromagnetic energy into thermal energy at the expense of conductivity losses and losses of stimulation of movements in magnetic and dielectric subsystems. It is well known that oxide ferrimagnetics, carbon black , carbonyl iron, dielectrics are widely used as active phase. Hexaferrites are widely used at microwave range because natural ferromagnetic resonance. Properties of this kind of materials are depend on, chemical composition [1 – 2], shape and size of particles [3 – 5], type of composition mixture.

II. MATERIALS

Hexaferrites of M-, W- and Z-type are most frequently used. Hexaferrites of W- and Z-type are used at wide range: from 10 to some hundreds GHz. They have high values of permeability and Curie temperature. But synthesis of these ferrites requires a lot of power inputs. M-type hexaferrites are working at high frequencies range (up to 100 GHz).

At the present work high frequency properties of composites based on M-type hexaferrite ($BaFe_{12}O_{19}$) with particles size less than 80 μm were investigated. M-type hexaferrite was obtained by self-propagating high-temperature synthesis [9 – 15]. Emulsion acryl paint and urethane alkyd lacquer were used as polymer.

Composites were produced as follows. Weighing of filler and polymer was made on the Shimadzu AUX – 320 scales. After that component parts of composite were compound and mixed using magnetic mixer till homogeneous state. Then mixture was treated by ultrasonic device with power 20 W and frequency 22 kHz for few minutes. Obtained composite was coated on plane metal surface in thin layer 1.1 mm. Polymerization of coating occurred at room temperature for one day.

Thus, composites coated on metal surface with maximum concentrations of ferrite filler were obtained. Concentrations of ferromagnetic powder are: 1) emulsion acryl paint – 60 weight percent $BaFe_{12}O_{19}$; 2) urethane alkyd lacquer – 70 weight percent $BaFe_{12}O_{19}$.

III. METHODS

Radiographic examinations were carried out on polycrystall diffractometer SHIMADZU XRD-6000 with realization of plotting geometry of photogram using Bragg-Brentano geometry. For quality analysis of phase composition computer base of data of X-ray powder diffractometry PDF4+ of international Centre for Diffraction Data was used. Quantity analysis of phase composition and revision of structure parameters of found phases were carried out using program of full-profile analysis Powder Cell 2.4.

Measurements of reflection coefficients of electromagnetic waves from composite plates putted on conducting substrate were carried out using vector network analyzer Agilent Technologis PNA-X N4257A and pyramidal horn antenna at frequency range 36 – 60 GHz.

TABLE I
THE STRUCTURAL PARAMETERS

Phase composition of samples, wt. %		Lattice constant, Å		Coherent-scattering region, nm	$\Delta d/d*10^3$
$BaFe_{12}O_{19}$	Fe_3O_4	a	c	86	1.3
98.6	1.4	5.91	23.31		

IV. Results and Conclusion

Roentgen fluorescent analysis of powders produced by self-propagating high-temperature synthesis showed that target phase contains 31.35 weight percent of Fe and 6.09 weight percent of Ba that corresponds to chemical composition Ba1.0Fe12.7O19.

On the Fig. 1 there are frequency dependencies of reflection coefficients for synthesized materials. Choice of current frequency range caused presence of natural ferromagnetic resonance of current hexaferrite at this frequency range. It is obvious that obtained materials have almost same curve shape. But containing of active component is less in the case of application of emulsion acryl paint. Frequency range on – 10 dB is 15 GHz.

Thus obtained material can be effectively used at microwave frequencies. Initial components were obtained by self-propagating high-temperature synthesis that sufficiently cheaper than standard ceramic technology.

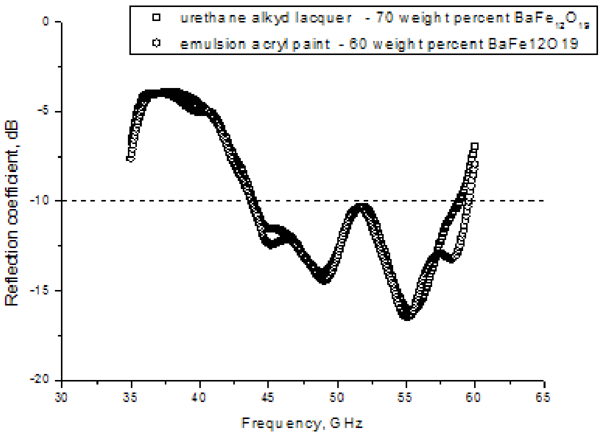

Fig. 1 Frequency dependencies of reflection coefficients for synthesized materials.

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