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ELECTRON BEAM MODIFICATION OF CHARACTERISTICS OF MN-ZN-FERRITE POWDER

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The paper discusses the influence of electron beam processing on the characteristics of Mn-Zn ferrite powder. The plots of spectrum reflec-

tance for the modified and original samples in the range from 700 to 1500 nm have a noticeable discrepancy. For the samples under study, a family of frequency dependences of the impedance and transfer coefficient was obtained. The analysis of electrical conductivity of samples showed a decrease in the resistance index of the modified sample by 2.43 times relative to the original one.
Keywords: electrical conductivity, Mn-Zn ferrite powder, transmission coefficient, reflection spectrum, ohmic resistance.

In order to increase the efficiency of radioelectronic equipment, methods aimed at changing the structure and properties of the surface and near-surface layers of ferromagnetic materials are used. Works [1, 2] propose methods for changing the characteristics and properties of solid ferrite products, represented by toroids, bars, cups, etc. The main disadvantage of these methods is the fact that the structural processing of a monolithic material is carried out to a relatively shallow depth (of the order of 150 μm).

We have proposed a technical approach in which electron-beam processing of a material in a powdered state takes place [3]. This approach allows uniform processing of the entire volume of the ferrite material. In the future, the modified Mn-Zn-ferrite powder can be used by the industry as an independent shielding/radio-absorbing coating. In addition, it can be used as an alloying additive for the formation of monolithic ferrite products. The purpose of this work is to analyze the degree of influence of electron beam processing on the characteristics and properties of magnetically soft Mn-Zn-ferrite powder.

As the object of study, we used polycrystalline Mn-Zn material N27, which has the following characteristics: the inductance coefficient A_L is 3270±25% nH, the initial magnetic permeability is 2000, the frequency range is from 0.025 MHz to around 0.15 MHz [4]. The source material was crushed to a powder state. The resulting powder contained fractions no larger than 0.2x0.13 mm. To process the obtained powder fraction, we used an electron-beam installation presented in [5].

The processing was performed by a fore-vacuum plasma electron source. An electron beam less than 1 mm in diameter has a power density of up to 105 W/cm2 at pressures in the vacuum chamber of the order of 5–20 Pa. The temperature during the processing reached about 600 °C with a heating rate of 100 °C/min. The total processing time was 10 minutes. The obtained material in the modified and original versions was studied using a Shimadzu UV-3600 Plus spectrophotometer [6]. To carry out the measurements, we made washers from the studied samples of materials. The resulting sample washers had a net weight of about 2.7 mg. Based on the data obtained, a graph of the reflection spectrum of the studied modified and original ferrite powders was plotted (Fig. 1).

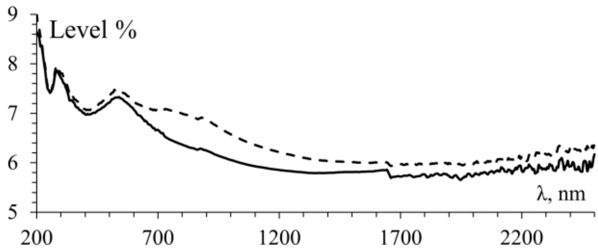

Fig. 1. Spectrogram of the studied samples of ferrite powder: original (---) and modified (—)

The sample measurement range was from 200 to 2600 nm. According to the results of measurements, in the wavelength range from 700 to 1500 nm, a significant difference was noted in the line of the modified powder relative to the original one. The analysis of the frequency dependences of the studied materials was performed using a vector network analyzer (VNA) P4226 «Panorama», with a connected coaxial camera [7].

Figure 2 and 3 show the frequency dependences of the impedance and transmission coefficients for the respective measurement options. It can be noted from the graphs that the transmission coefficient lines of the modified and original powder samples differ by about 6% in some frequency ranges. In this case, the dependence of the impedance samples at some peak frequencies fluctuates in the range from 2 to 9 ohm.

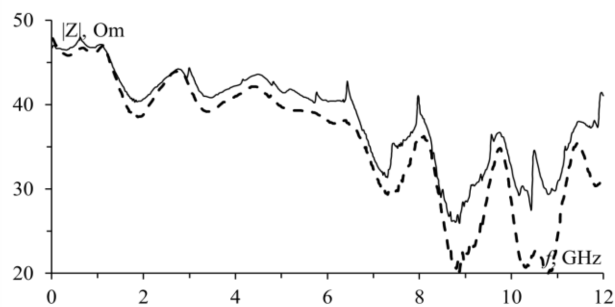

Fig. 2. Frequency dependences of impedance curves, chambers with original sample (---), chambers with modified sample (—)

Further, each of the samples was pressed into cylinders with dimensions of 14×14 mm. Then, a Rohde & Schwarz immittance meter (model Hameg HM8118) was connected to the samples, using wire contacts. According to the results of the experiment, it was found that the ohmic resistance of the original sample is 17 Ohm. The modified powder sample showed an ohmic resistance value of 7 Ohm. Thus, the value of the ohmic resistance of the modified sample is 2.43 times lower than the original one.

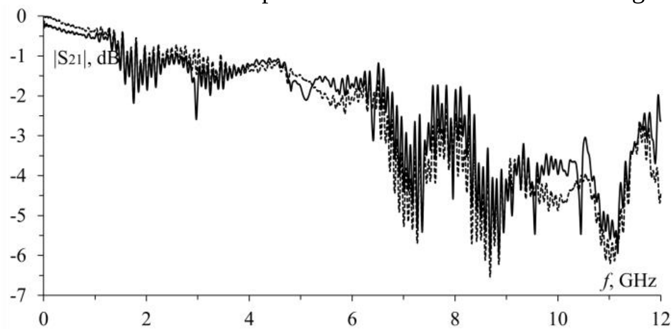

Fig. 3. Frequency dependences $|S_{21}|$: chambers with original sample (---), chambers with modified sample (—)

In this article, we investigated the effect of electron beam processing on the characteristics of Mn-Zn ferrite powder. We presented the graphs of the reflection spectrum, which show a significant difference between the line of the modified powder relative to the original one in the wavelength range from 700 to 1500 nm. Such a difference in the results is explained by a change in the composition of the substance during electron beam processing, as well as the presence of doping and binding impurities in the composition of the initial sample of the ferrite material.

The frequency dependences of the impedance and modulus S_{21} of the samples under study were also obtained. It is noted that the curves of the transfer coefficients of the modified and original powders are almost identical. In this case, the impedance curves reach a noticeable difference, which at some peak frequencies varies in the range from 2 to 9 ohm. The ohmic resistance of cylinders from the material samples was measured, according to the results of which the modified sample showed a decrease in ohmic resistance by 2.43 times relative to the original one.

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QUASISTATIC ANALYSIS OF AN MR-BASED STRUCTURE WITH CONDUCTORS ON THE OUTER LAYER OF THE PCB

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This paper presents the analysis of the characteristics of the structure with conductors on the outer layer of the printed circuit board (PCB) with modal reservation (MR). The authors consider the dependences of the difference of per-unit-length delays and the geometric mean impedances of the modes on the structure parameters. Recommendations for changing the geometric parameters to maximize the difference of per-unit-length delays are proposed.

Keywords: electromagnetic compatibility, modal reservation, printed circuit board.

When printed circuit boards (PCB) are created for critical electronic equipment, much attention is paid to electromagnetic compatibility and functional safety of electronic circuits [1]. Redundancy is a cardinal method for improving functional safety. Cold redundancy differs from hot redundancy in that if the reserved system fails, it switches over to the reserving system that was switched off. However, redundancy does not protect against the effects of systematic electromagnetic interference (EMI), since if the reserved system fails due to EMI, the reserving system will also fail.

Ultrashort pulses (USPs), which have high energy, are of short duration. To prevent the influence of USPs, technologies based on modal filter-