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MODIFICATION OF FREQUENCY SPECTRA OF FERRITE COMPOSITES

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Abstract: *Short abstract*
The paper is devoted to the study of NiZn ferrite prepared by means of ceramic technology. In addition the NiZn ferrite was used as filler in PVC matrix to preparation novel materials for various microwave applications. In the case of NiZn ferrite polymers the relaxation type of frequency permeability dispersion is shifted to higher frequencies due to decreasing of ferrite particle content.

Key words: *ferrite, ferritepolymers, complex permeability spectra, demagnetizing field*

INTRODUCTION

In this paper we can present the role played by ferrites in investigating the magnetization processes. We treat the same subject from the point of view of relation between theoretical ideas and experimental results. In a polycrystalline ferrite and magnetopolymer the ionic and granular structures led to a lower conductivity which permits the material to be investigated easily up to high frequencies [1, 2, 3]. We can find the materials used over large frequency range, but without any external bias field. The most important ones have been nickel-zinc ferrites, Li ferrites and later the garnets also.

In these materials it is possible to carry out investigations vs. frequency in natural conditions, where the internal field is determined only by spontaneous magnetization and the anisotropies.

1 EXPERIMENTAL RESULTS

The initial susceptibility, lower in ferrites than in metals, have been attributed to the spin rotation in the domains, the fact that primitively the frequency spectra showed only one dispersion seemed to confirm this conclusion, since the spins need no special conditions to exist, contrary to the domain walls, the single dispersion was attributed to the natural spin resonance.

The permeability dispersion of polycrystalline ferrites is associated with various mechanisms of magnetization. They are the domain wall displacement; the magnetization rotation and the gyromagnetic spin rotation due to the effective anisotropy field. Frequently, because of the interplay between these mechanisms, it is hardly possible to distinguish between the contributions of these processes to permeability dispersion and to determine its frequency operation region with adequate degree of accuracy.

The measured [4] magnetic spectra of sintered $Ni_{0,36}Zn_{0,64}Fe_2O_4$ ferrite prepared by ceramic way with relatively high initial permeability and low total anisotropy are shown in Fig. 1a, b

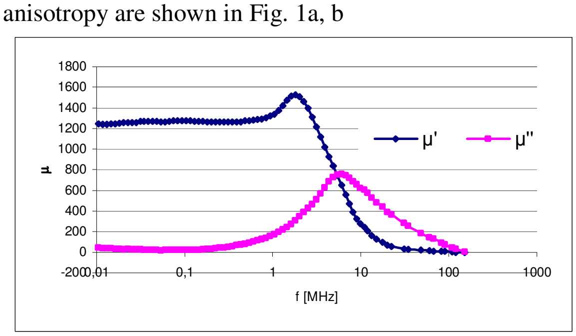

Fig.1a: The frequency spectra of real μ' and imaginary μ'' components for sintered NiZn Ferrite

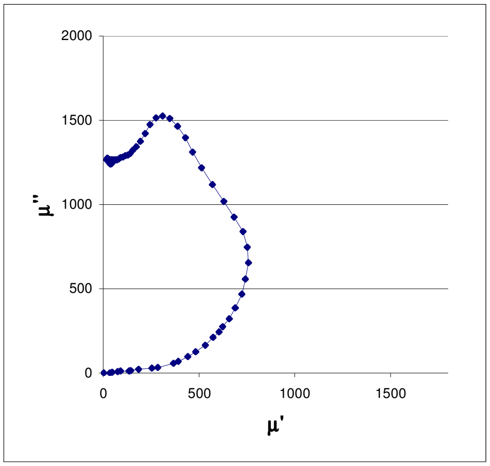

Fig.1b: The frequency spectra of complex permeability spectra μ for sintered NiZn Ferrite*

The real part μ'(f) of complex permeability is characterized by dispersion characteristic, which results from the contributions of the resonance-type of domain wall motion superimposed over the relaxation-type d.w. displacements through magnetization. This resonance may be explain phenomenon by the existence of demagnetizing fields due to a worse grain axis continuity and to larger thickness of the grain boundaries. The real part μ' is above 1200 in the low frequency region up to 1MHz, then it value increase uo to resonance maximum at frequency of f_0=2,5MHz, due to relaxation-type d.w. displacement. The imaginary part of permeability μ''(f) gradually increases with frequency and has a broad maximum of about 790 at relaxation frequency f_r=6,5MHz, where the μ'(f) has roughly inflection point. The complex permeability data μ*(f) are approximated by a complex plane locus in plane where the real part μ'(f) of complex permeability is plotted against the imaginary part μ''(f).

For polymer composite materials based on PVC matrix and $Ni_{0,36}Zn_{0,64}Fe_2O_4$ ferrite particles with average diameter <D>=250μm, the dispersion frequency increases as the ferrite content decreases from 80 to 20 vol. %. The values of μ'(f) drops with decreasing of the μ'(f) particle vol. % concentration, see Fig. 2a, 3a and 4a, there the μ'(f) and μ''(f) spectra behaviors are presented for selected particle filler content κ_v=80, 60 and 30 vol. %.

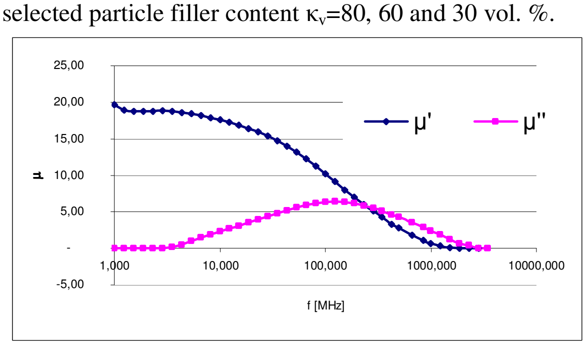

Fig.2a: The frequency spectra of real μ' and imaginary μ'' components for sintered NiZn Ferritepolymer with κ_v=80%

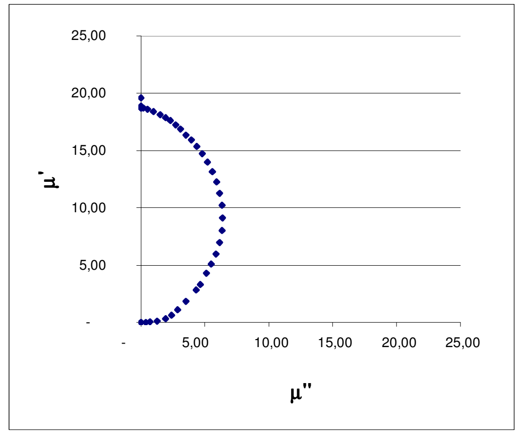

Fig.2b: The frequency spectra of complex permeability spectra μ for sintered NiZn Ferritepolymer with κ_v=80%*

A decrease of filler content leads to shift in the relaxation frequency f_r of maximum the imaginary part μ''(f) behaviors to higher frequencies. This is accompanied by a decrease in μ'(f) and μ''(f) values and with broaden μ''(f) maximum.

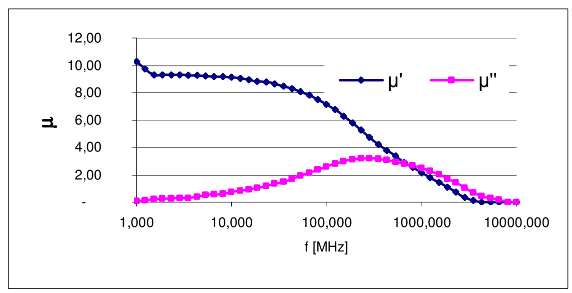

Fig.3a: The frequency spectra of real μ' and imaginary μ'' components for sintered NiZn Ferritepolymer with κ_v=60%

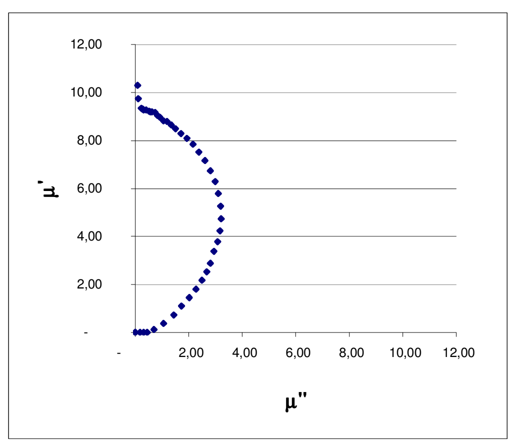

Fig.3b: The frequency spectra of complex permeability spectra μ for sintered NiZn Ferritepolymer with κ_v=60%*

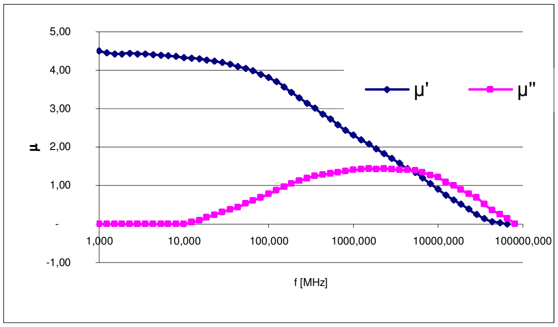

Fig.4a: The frequency spectra of real μ' and imaginary μ'' components for sintered NiZn Ferritepolymer with κ_v=30%

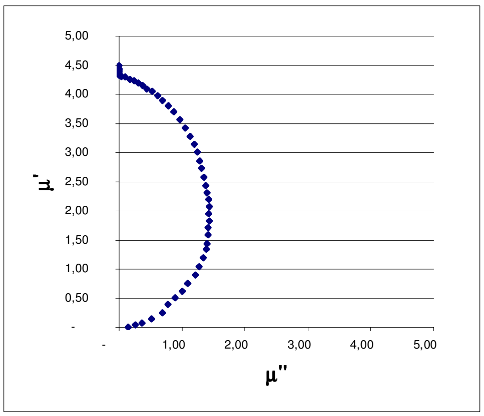

Fig.4b: The frequency spectra of complex permeability spectra μ for sintered NiZn Ferritepolymer with κ_v=30%*

The maximum magnetic loses (maximum of μ'') in the composite decrease as the concentration ferrite particles decreases and relaxation region shifts to higher frequencies. As a result the relaxation frequency f_r shifts from 6MHz to about 1GHz. The experimental data of complex permeability the ferritepolymer samples are plotted by three sets of complex plane loci in Fig. 2b, 3b and 4b for ferrite particle contents κ_v=80, 60 and 30 vol. %. These loci can be fitted by circular arcs and show considerable deviations from the semicircular loci, which are typical for a pure Debye relaxation theory. The loci decrease with decreasing of filler concentration κ_v. In polymer-ferrite composites, the non-magnetic matrix cuts of intrinsic magnetic properties of particles an as a result, changes the internal magnetic field in the composite. Therefore, compared with sintered ferrites, ferritepolymers are characterized by a radically different dispersion of permeability. As example, the composites have the primitively frequency spectra μ*(f) showed only one dispersion due to relaxation process only, contrary to the μ*(f) spectra of sintered NiZn ferrite in Fig. 1a, b. The surface of ferrite particle has irregular structure, booth of a geometric and crystallographic mature, i.e. surface roughness, cracks, pores, impurities etc. The porosity is a parameter has been applied to the study of behaviors of ferrites and ferritepolymer composites. The intragranular porosity plays the same role in both the sintered ferrites and the composites. For initial permeability that results in drastic decrease. When the sample is submitted to larger exciting ac. field i.e. in the case of non-reversible processes, the wall motion is still disturbed resulting in losses which lead to the increase of the measured coercivity.

Porosity seemed to be a important parameter to study the magnetization processes in ferrites, in which it is very large. Polycrystalline ceramics are formed from agglomerate of particles. In this case the high porosity of starting material which is practically only an intergranular porosity decreases during sintering process as a consequence of grain growth mechanisms.

So, the total porosity has been measured [5] on NiZn ferrites was practically due intragranular porosity, contrary to the intergranular porosity, which play a minor role in magnetization mechanisms. From this point of view similarly situation with total porosity is in ferritepolymer composites.

The ferritepolymer composite manifest itself as the magnetic system with the reduction of the low-frequency part of permeability, reduction the magnetic losses and the shift of the relaxation (or resonance) to higher frequency. This is due to particle size and total porosity which case demagnetizing field. The demagnetizing field led to the pinning of the domain walls in particles and, hence, to the damping of d.w. motion under an external magnetic field. As a result, the low-frequency part of permeability associated with motion of domain walls, decreases, and ferromagnetic resonance (relaxation) shift to higher frequencies. on the other hand, our opinion is, that the magnetization rotation mechanisms carry out rather than d.w. motion in studied NiZn ferritepolymers. Then the shift of ferromagnetic resonance frequency reaches a value of order $g\left(\overline{H}_a + \overline{H}_d\right)$, where g is magnetomechanical ratio, $\overline{H}_a$, $\overline{H}_d$ are magnetostructural anisotropy field and demagnetizing field.

2 CONCLUSION

Novel magnetic dielectric materials have been developed on the basis of polycrystalline NiZn ferrite particles and PVC matrix. NiZn ferrite changes the character of frequency dispersion of permeability, which manifests itself in a shift of the relaxation frequency from the MHz closer to the GHz range, accompanied by a decrease in the low-frequency permeability. From the theoretical point of view there are several mechanisms that may be responsible for variation of permeability, shift of frequency dispersion and decrease of magnetic losses. There are the changes of domain structure in particles and pinning of domain walls due demagnetizing field and pores volume of particles with consequence that magnetization rotation mechanisms carry out probably in novel materials. There are some facts for application of these ferritepolymers:

1. Compared with a sintered NiZn ferrite, NiZn ferritepolymer composite is characterized by a higher frequency range of dispersion.

2. By appropriate choice of size of filler particles, polymer matrix and concentrations of particles, one can design NiZn ferritepolymer composites with the

dispersion of permeability in the microwave range of frequencies.

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