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STRUCTURAL, DIELECTRIC AND MAGNETIC PROPERTIES OF MANGANESE-ZINC FERRITES

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Abstract: Manganese-zinc ferrite ($Mn_{1-x}Zn_x Fe_2 O_4$) samples were made using a classical ceramic technology procedure. Appropriate amounts of the compounds were mixed and ground, heated, pressed and sintered. Ðstructural properties were obtained using an X-ray method employing a Phillips diffractometer with graphite monochromator. It was confirmed that the samples were single phased. Magnetic properties were measured and compared with standard Phillips products. Dielectric properties were studied in the infrared and far infrared ranges, on the basis of reflectivity measurements which were numerically analyzed. Three ionic resonances were observed in the range between 800 and 300 cm^{-1} The values of the dielectric permitivitty were calculated and the results obtained were discussed and compared with published data obtained at much lower frequencies for 172 MHz, ε_r=57.2/1/, and for 4.5 GHz, ε_r=9.3/2/.

INTRODUCTION:

Ferrites are ceramic ferromagnetic materials made from ferrous oxide and bivalent metal oxide as ZnO.MnO,NiO etc. Compared with ferromagnetic materials they have the following advantages: (a) high values of initial permeability, high specific electric resistivity which enables their use at high frequencies and finally the technology of their production is easy and relatively cheap; (b) ferrites are very suitable materials for making electric components the properties of which do not change during exploitation for more than 10 years; (c) magnetic soft ferrites have the basic formula MFe_2O_4 where M is a bivalent metal such as : Mn, Zn, Ni, etc. Manganese-zinc ferrites ($Mn_{1-x}Zn_xFe_2O_4$) are very often used in a wide frequency range, because they have large initial permeability, usually above 750.

EXPERIMENTAL:

Our samples were made when appropriate amounts of Fe_2O_3, ZnO and $MnCO_3$ were dry mixed. annealed, then ground, pressed into the required shape and finally sintered at 1330±10 C in a nitrogen atmosphere. Several different compositions were made with 6, 12.5, 18.7 and 28 mol% ZnO.

The electromagnetic characteristics of the sample were measured on torus-shaped specimens and their values are given in table 1. for samples of $Mn_{1-x}Zn_xFe_2O_4$.

TABLE 1.

*Sample No.	(1)	(2)	(3)	(4)
Permeability (μ_i)	2000	2000	900	3800
Frequency range (KHz)		100	200-500	.001-.5
($tg\delta/\mu_i$) 10^{-6}		≤10	10-100	25-10
B (T=25° C, H=3000 A/m)	470mT	400mT	390mT	410mT
Coercitive field (A/m)	20	20	30	18
ρ (Ω/m)	1	1	0.1	0.3
Specific weight (kg/m³)	4900	4900	4900	4900
Critical temper. (°C)	>200	≥190	≥150	>100
Lattice parameter (nm)	.8494(2)	.8492(4)	.8489(3)	848(3)

* (1) $Mn_{0.94}Zn_{0.06}Fe_2O_4$, (2) $Mn_{0.875}Zn_{0.125}Fe_2O_4$,
(3) $Mn_{0.813}Zn_{0.187}Fe_2O_4$, (4) $Mn_{0.72}Zn_{0.28}Fe_2O_4$

The content of Zn atoms was obtained employing X-ray powder method using a Phillips diffractometer with a graphite monochromator. Diffractograms are obtained for solid samples and also when part of them were ground. The unit cell for each sample was calculated using the measured Bragg's reflection, extrapolation function $\cos^2\theta$ and the least square method. The values of the lattice parameter (a) as a function of composition and Vegard's line are plotted against composition in figure 1. with ASTM values for the end compounds $ZnFe_2O_4$ /3/ and $MnFe_2O_4$ /4/ respectively.

It is very interesting that the standard deviation is smallest for the sample with 6 mol% Zn which has the highest value of magnetic induction as well. Samples number (2) and (3) with higher contents of Zn have less sharp Bragg's reflections. A part of the diffractograms for Bragg's reflection (333) which appears at about $2\theta=56^{\circ}$ is given in figure 2. for all the examined samples. The samples with 6 mol% Zn has very well parted α_1, and α_2 reflections, which is not the case for the other samples. This also suggests and confirms that sample number (1) was the best crystallized one. To confirm this we also examined Bragg's reflection diagrams for solid plates of these four samples. In figure 3. are given these Bragg's reflections around $2\theta=30^{\circ}$, where we can see that a characteristic Bragg's reflection angles at about 30° and 33.3°, for sample (2) and (3) while samples (1) and (4) had no reflection at 33.3°. Bragg's reflection at about 30° comes from a spinal lattice but the other reflection (at 33.3°) represents hematite (α-Fe_2O_3) and appears only at the surface of the poorer quality samples.

Dielectric properties in the infrared and far infrared were investigated on the basis of reflectivity measurements of polished samples. The reflectivity curves against wavwnumber in the infrared region for samples (1) and (2) are given in figure 4. and these measurements were made using a Perkin-Elmer 983G spectrophotometer. In this region three strong oscillators were observed while in the far infrared range the reflectivity did not change and retained a constant value at about 23%. These diagrams were numerically analyzed and the dielectric permitivitty calculated. The change of both the real (ε_1) and imaginary (ε_2) part of complex dielectric permitivitty with wave number is given in figure 5.

DISCUSSION:

To compare our experimental results in the infrared region, the number of active infrared modes were calculated using Adams-Newton tables. Since the lattice is spinel and space group O_h^7 the complete number of infrared active modes is four.

In figure 5. we actually see all four infrared active modes at the wave numbers of about: 280, 320, 380 and 555 cm^{-1}. It is important to notice that value of the dielectric permitivitty is about 8,5 at the frequency much lower compared with infrared region where there are present four ionic resonances. This is in good agreement with the literature data ε_r=9.3 for the frequency at about 5GHz. $Mn_{1-x}Zn_xFe_2O_4$ ferrites have got relatively high dielectric permitivitty in a very wide frequency range and that might be interesting for practical applications.

LITERATURE:

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