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The effect of different annealing temperatures on structural and dielectric measurements of $Mg_{0.5}Zn_{0.5}Fe_2O_4$ prepared by chemical co-perception method

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ABSTRACT

In this paper, the preparation and same physical properties of $Mg_{0.5}Zn_{0.5}Fe_2O_4$ sample at different temperatures. Ferrite samples were studied prepared by chemical co-perception method at room and different temperature (300, 600, 900, and 1200) ^oC at 2hr. The nature of crystallization of the compounds was examined by using X-ray diffraction technique which showed that the prepared ferrite samples are poly-crystalline cubic structures. To obtain the dielectric measurements, the real part dielectric constant, imaginary part of dielectric constant and dielectric loss were recorded in the frequencies range 100Hz-5MHz. The variation of real part , imaginary part of dielectric constant as a function of frequency shows relaxation as Debye relaxation.

1- Introduction

The continuous search for new, better properties has led to the discovery of previously unknown materials, and with the availability of these materials many uses have emerged based on their unique properties [1]. Magnetic ceramics, such as Ferrite's, are one of these materials that have evolved into the components of the construction of electrical circuits operating at low and high frequencies [2]. The cubic sprites are spelled and are called ($MeFe_2O_4$ or $MeOFe_2O_3$) (where Me is divalent metalion) To any bivalent metal belonging to the transition elements of the periodic table (Cubic structure is taken to balance negative and positive charges and is tightly packed with oxygen ions with two or two valence ions (Fe^{+3} and distributed in the binary crystal structure will also come Rah installation Lariats in Part II, and from here naming this type of Lariats as "Fright Alspinl" and is ferrite spinel commercially important materials because they possess magnetic and electrical properties [3]. Shahida Akhter and his group prepared the nanoparticles of $NiFe_2O_4$ by chemical deposition at 275 ° C, 450 ° C and 600 ° C for 2hr. They also used the XRD technique for the structural and plastic characterization of this product. The samples, And found that particle size increased from (10nm) to (23nm) with increasing temperatures. They also studied electrical properties as a function of frequency. They found that the true and imaginary electrical insulation constant and the angle of loss remained with increasing temperature [4] In the same year, the researcher Zhan gatharan and others studied the structural and electrical properties of ferrites $Co_{(0.5-x)}Ni_xZn_{0.5}Fe_2O_4$ (x = 0.0,0.1and 0.2) prepared by chemical deposition method at different temperatures. Note that all samples have a face center cubic structure (FCC) was also decreased with the increase in nickel concentration and they explained the decrease in (ε ') due to the increase in the particle size and density (ρ_{x-ray}) Fe^{2+} ions from sites B to (A). They also studied σac as a function of frequency, observing the natural behavior of any samples increases with increasing frequency [5].

2- Experimental details

The selected composition $Mg_{0.5}Zn_{0.5}Fe_2O_4$ was synthesized using the chemical co-perception method, using of high purity (AR grade) magnesium nitrate $[Mg(NO_3)_3.\ 9H_2O]$, znic nitrate $[Zn(NO_3)_2.6H_2O]$ and iron nitrate $[Fe(NO_3)_3.\ 9H_2O]$, were separately dissolved in doubly distilled water with constant stirring at room temperature, and then mixed together. Finally, the solution containing all the elements was obtained. This solution was precipitated with NaOH solution having pH=12 at 60 ^oC with constant stirring. The precipitates so obtained were washed several times and filtered in order to remove organic content from the precipitates and the filtrate so obtained was dried in oven at 100 °C for 12 hr. The powder was crushed and mixed with PVA (poly vinyl alcohol) as organic binder and then pressed into pellets of 10 mm diameter and 2-3 mm in thickness. The pellets so obtained were sintered at room temperature and annealed at different temperatures ranging from 300 °C to 1200 °C for 2 hr in air. X-ray diffraction patterns of samples were recorded using X-ray diffractometer (model Bruker D8 Advance) with Cu-kα (λ=1.5418Å) radiation, with a slit of divergence of 1° and a receiving slit of 0.2 was used with a '2θ' scan step of 0.02. the powder was uniforms spread on a screen mount. The scan rate was 0.4 sec/step and recording was made in 20° to 80° range of '2θ'. Dielectric measurements were carried out using LCR Meter Bridge (model HIOKI 3532-50 LCR Hi TESTER) in the frequency range 100 Hz to 5 MHz at room temperature. The dielectric constant (έ) was calculated by using the formula [6].

$$\varepsilon' = \frac{C_P \times d}{\varepsilon_o A} \text{ ------------ } (1)$$

where C_p is parallel plate capacitance in PF, d is thickness of the pellet in cm, A is area of cross section of pellet = πr^2 (r is radius of the pellet in cm) and ε_o is constant of permittivity of free space (ε_o = 8.85×10^{-12} F/cm). The variation of the real part of dielectric constant, imaginary part of dielectric constant and dielectric loss with frequency was studied.

3- Results and discussions

3-1 Structural analysis

The X-ray diffraction patterns of $Mg_{0.5}Zn_{0.5}Fe_2O_4$ ferrites at room and different temperature (300, 600, 900, and 1200) °C are shown in Fig. 1. It was for all samples clearly indicate formation of crystallite phase. The XRD-patterns show absence non-reacted products or intermediate crystalline phases. The positions of all the Bragg peaks were used to obtain the inter-planer spacing. The peaks were indexed by comparing the inter-planer distance with the JCPDS data for $Mg_{0.5}Zn_{0.5}Fe_2O_4$ samples (Card No. 10-325) [7].

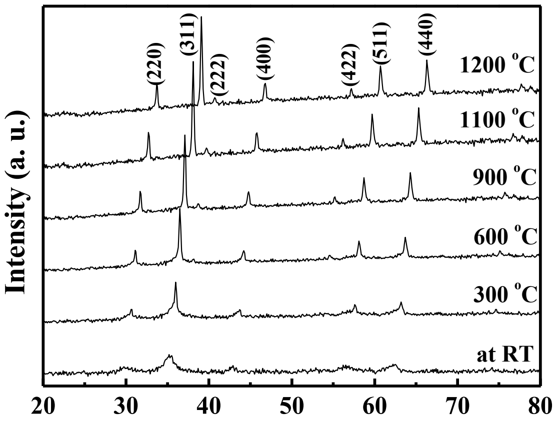

Fig.1. XRD patterns of $Mg_{0.5}Zn_{0.5}Fe_2O_4$ pellets sintered at RT, 300 °C, 600 °C, 900 °C and 1200 °C at 2 hr.

3.2 Dielectric measurements

The effect of frequency on dielectric constant (έ) at room temperature for all samples is illustrated in Fig. 2. From Fig. 2, it is clear that dielectric constant decreased with increasing frequency and finally at higher frequencies attains almost constant value for all the samples. This is obvious because of the fact that the species contributing to the polarize-ability are lagging behind the applied field at higher frequency. The variation of dielectric constant with frequency reveals the dispersion due to Maxwell-Wagner [8-9] type interfacial polarization, which is agreement with Koop's phenomenological theory [10]. The large values of dielectric at lower frequency are mainly due to presence of all type of polarization i.e. $P_{total} = P_e + P_i + P_d + P_{sc}$ where subscripts indicate the electronic, ionic, dipolar and space charge contributions respectively. According to Abdulsamee et al [11], the polarization in ferrites is through a mechanism similar to the conduction process. The exchange of electrons between ferrous ions (Fe^{2+}) and ferric ions (Fe^{3+}) on the octahedral site may lead to local displacement of electrons in the direction of applied field and these electrons determine the polarization. The polarization decreased with increasing frequency and then reaches a constant value due to the fact that beyond a certain frequency of external field the electron hopping cannot follow the alternating field.

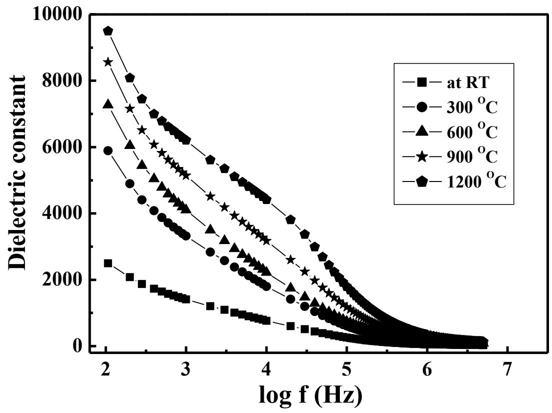

Fig. 2. Frequency dependence of the real part of the dielectric constant, at RT and different temperature 300 °C, 600 °C, 900 °C, and 1200 °C .

Dielectric loss of a material arises due to the imperfections and impurities in the crystal lattice. The lagging of polarization behind the applied alternating field increases the dielectric loss [12]. Fig. 3 shows the dielectric loss (tan δ) as a function of frequency at room temperature for all samples. It can be seen that the dielectric loss decreases with increasing frequency and becomes minimum high frequency increases [13]. At some lower frequency, resonance occur which shows that high permeability appears at lower frequencies.

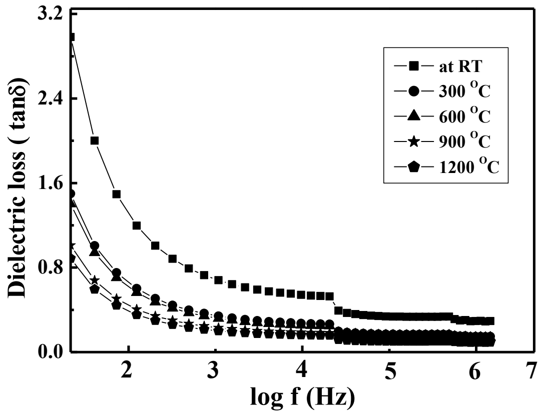

Fig. 3. Frequency dependence of the dielectric loss, at RT and different temperature 300 °C, 600 °C, 900 °C, and 1200 °C .

The frequency dependence of the imaginary part of the dielectric constant is given on Fig. 4. For all samples the value of imaginary part of dielectric constant is relatively at low frequencies. Also It shown small dispersion with increase in frequency up to 4 KHz and remains fairly constant afterwards for all samples under study [14].

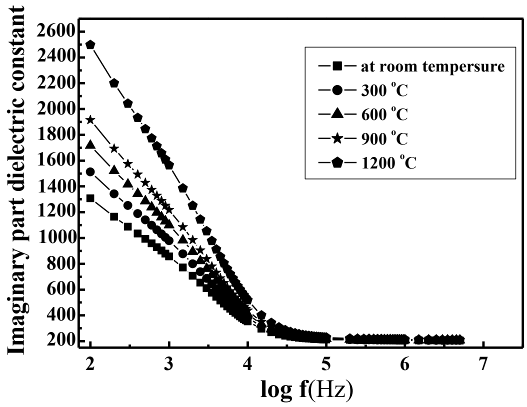

Fig. 4. Frequency dependence of the imaginary part of the dielectric constant, at RT and different temperature 300 °C, 600 °C, 900 °C, and 1200 °C .

Conclusions

In the present work, we have successfully synthesized $Mg_{0.5}Zn_{0.5}Fe_2O_4$ ferrites by chemical co-precipitation method by using a NaOH precursor. The synthesized materials were sintered for various temperatures in the temperature range RT to 1200 °C to optimize the possible minimum sintering temperature for phase formation. In the structural study of $Mg_{0.5}Zn_{0.5}Fe_2O_4$ ferrites, crystalline nature is confirmed by X-ray diffraction. The Bragg's peaks observed in XRD plots are matching with the JCPDS data which indicates that the materials formed are of single phase having inverse spinel cubic structure. Decrease in the real part of dielectric constant, the imaginary part of the dielectric constant and dielectric loss with increase in frequency for all samples suggests the dielectric dispersion behavior.

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تاثير درجات حرارة التلدين المختلفة على القياسات التركيبية والعزلية لمركب $Mg_{0.5}Zn_{0.5}Fe_2O_4$ المحضرة بطريقة الترسيب الكيميائي

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الملخص

في هذا البحث تم تحضير ودراسة بعض الخصائص الفيزيائية $Mg_{0.5}Zn_{0.5}Fe_2O_4$ عند درجات الحرارة المختلفة. نماذج الفرايت قيد الدراسة حضرت بطريقة الترسيب الكيميائي عند درجة حرارة الغرفة ودرجات حرارية مختلفة ^{o}C (300, 600, 900, 1200) عند زمن ساعتين . تم أجراء الفحص التركيبي للنماذج باستخدام تقنية حيود الاشعة السينية أذ تبين ان جميع النماذج الفرايت ذات تركيب بلوري مكعبي . كما تم دراسة القياسات العزلية المتمثلة بالجزء الحقيقي والخيالي لثابت العزل الكهربائي وكذلك خسارة العازل ضمن المدى الترددي 100 – 5 ميكاهيرتز . لقد لوحظ ان تغير الجزء الحقيقي والخيالي كدالة للتردد يعطي استرخاء مشابه لاسترخاء ديباي.