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DIELECTRIC BEHAVIOUR OF (MG-CR) SPINAL FERRITE WITH DIFFERENT FREQUENCY

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ABSTRACT

The samples of $MgFe_{2-x}Cr_xO_4$ spinal ferrite systems with varying x [x=0.0-1.0] were synthesized via wet-chemical co-precipitation techanique.The Knowledge of dielectric loss in ferrite is considered to be originated from two mechanisms namely electron hopping and charge defect dipoles. Electron hopping contributes to the dielectric loss mainly in the low frequency region. In the high frequency region the dielectric loss mainly results from the response of defect dipole to the field. These dipoles in ferrites are found due to the change of cation valance state such as Fe^{3+}/Fe^{2+}, Mg^{2+}/Mg^{3+} during sintering process.

KEY-WORDS- Ferrire, wet-chemical co-precipitation techanique, dielectric loss dielectric constant.

1. INTRODUCTION

Recent interest in the study of several spinel type ferrites which are characterized by high electrical resistivity, high dielectric constants and low losses [1]. Due to wide range technological applications especially at high frequency ranges; the ferrites have been attracting the researchers in large number [2,3,4]. $MgFe_{2-x}Cr_xO_4$ is a normal spinel ferrite. The synthesis of nano particles at low temperature by various methods in view of the potential applications of these nano size magnetic materials in different technological areas [5, 6]. Synthesis and application of magnetic nano particles is subject of interest of several researchers because of their unique properties that makes them attractive and interesting from scientific view and technological significance of enhancing the performance of the existing materials [7, 8]. The nano-size materials exhibit unusual physical and chemical properties significantly different from those of their bulk counter part because of their extremely small size and large specific area [9, 10]. Nano-size ferrites with uniform particles size and narrow size distribution are desirable for a variety of applications viz. magnetic data storage ferro-fluids, medical imaging, drug delivery etc. [11, 12], so their synthesis and characterization have attracted increasing attention in the last five years. The ability to produce nano size magnetic materials has opened new applications for magnetic materials.

Magnesium ferrite, $MgFe_2O_4$ is a soft magnetic n-type semi-conducting material [13], which finds applications in absorption, sensor and in magnetic technologies. According to crystal structure $MgFe_2O_4$ is inverse spinel ferrites whose degree of inversion depends on the heat treatment. In the present study, Chromium substituted magnesium ferrite ($MgFe_{2-x}Cr_xO_4$) system is prepared by wet chemical co-precipitation technique. The aim of present work is to study dielectric loss in ($MgFe_{2-x}Cr_xO_4$) ferrite prepared by wet chemical co-precipitation method.

2. EXPERIMENTAL DETAILS

The samples of $MgFe_{2-x}Cr_xO_4$ with varying x (x = 0.0 to 1.0) were synthesized by wet-chemical co-precipitation technique. AR grade sulphates of the constituent ions were used for the preparation of Mg-Cr spinel ferrite system. The solutions of sulphates were prepared using stoichiometric molar proportions. The solutions were mixed together and allowed to settle for 24 hours and the initial pH of the solution was measured. Two molar NaOH solution was prepared and slowly added to the mixed solution of sulphates. H_2O_2 was also added to the mixed solution to increase the oxidation reaction. The mixed solution was constantly stirred and heated at low temperature (60^0C) during the addition of NaOH and H_2O_2. NaOH was added until the precipitation of dark brownish colour is formed and pH of the precipitation was measured. The precipitation was washed several times by acetone and then by double distilled water several times. The solution was filtered to get fine particles of Mg-Cr spinel ferrite system. The fine powder of Mg-Cr spinel ferrite system is then heated at 150^0C for four hours to remove water molecules. The fine powders were sintered at 800^0C for 12 hours.

All the synthesized powders were characterized by using X-ray diffraction technique. Microstructure and surface morphology of all the samples were studied using Scanning Electron Microscope (JEOL JSM 840). IR spectra were recorded using Parkin - Elemer Spectrometer (Model No. 783) in the wave-number from 350-800 cm^{-1} by KBr pellet method.Each of the sintered discs was polished before electrical measurement for ensuring a good electrical contact. The a.c. / d.c. electrical measurement were carried out in the temperature range 300-800 ^{0}C using two probe method. The dielectric properties were measured as a function of composition and frequency using LCR-Q meter.

3. RESULT AND DISCUSSION

Figure shows the variation of dielectric constant as a function of frequency for $MgFe_{2-x}Cr_xO_4$ samples. The significant dispersion in dielectric constant is observed at lower frequency region for all the samples. The extent of dispersion is affected by Cr^{3+} content. The mechanism of dielectric polarization is similar to that of conduction process. It has been concluded that the electron exchange between Fe^{2+} and Fe^{3+} results in the displacement of charges in the direction of an electric field, which is responsible for polarization in ferrite [15, 16]. With increasing the frequency of the externally applied field, the electronic exchange between Fe^{2+} and Fe^{3+} cannot follow the alternating field, resulting the decrease in dielectric constant.

Figure gives the variation of dielectric loss tangent with frequency for all the samples of $MgFe_{2-x}Cr_xO_4$. Similar to dielectric constant, the dielectric loss tangent also exhibits dispersion in low frequency range and is affected by Cr^{3+}ions. The dielectric loss in ferrite is considered to be originated from two mechanisms namely electron hopping and charge defect dipoles. Electron hopping contributes to the dielectric loss mainly in the low frequency region. In the high frequency region the dielectric loss mainly results from the response of defect dipole to the field. These dipoles in ferrites are found due to the change of cation valance state such as Fe^{3+}/Fe^{2+}, Mg^{2+}/Mg^{3+} during sintering process. The relaxation of dipoles under electric field is decreased with increasing frequency resulting in decreasing dielectric loss tangent in high frequency region.

Figure 1,2 and 3 respectively gives the variation of dielectric constant (□'), dielectric loss (□'') and dielectric loss tangent (tan□ □ as a function of temperature at a frequency of 1 -10KHz. The dielectric constant, dielectric loss and dielectric loss tangent all increases with increase in temperature. Our results are similar to the other well-known spinel ferrites [17, 18] for which □' □''and tan□ increases with increasing temperature.

4. CONCLUSION:

Synthesis of Mg-Cr spinel ferrite was successful carried by wet- chemical co precipitation technique. The relaxation of dipoles under electric field is decreased with increasing frequency resulting in decreasing dielectric loss tangent in high frequency region. Dielectric properties show strong frequency as well as temperature dependence.

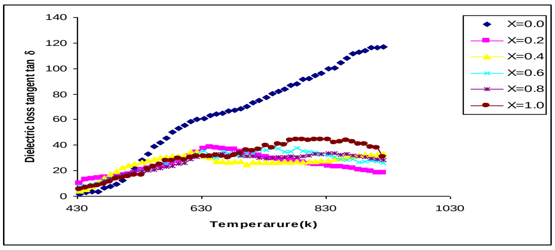
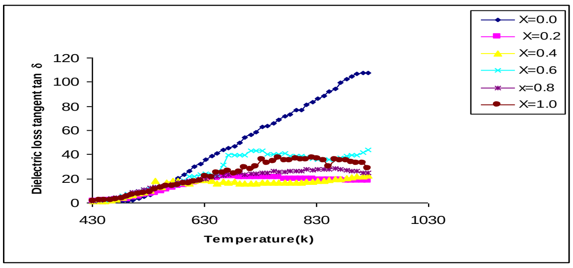


Fig.1. The variation of dielectric loss tangent (tan**δ)** as a function of temp at 01-10 khz



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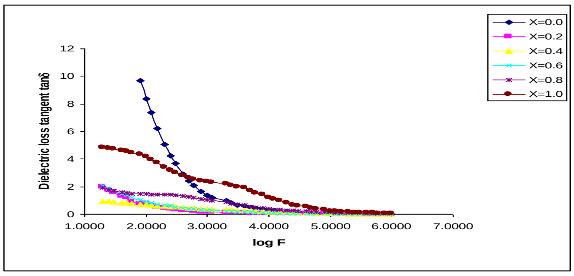

Fig. 3. Variation of Dielectric loss tangent (tan δ) with Log F

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