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DIELECTRIC PROPERTIES OF STRONTIUM HEXAGONAL FERRIT

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Abstract:

The M-type strontium hexagonal ferrite with molecular formula $SrCe_xDyFe_{11-x}O_{19}$ for x=0.00, 0.25, 0.50, 0.75 and 1were prepared by sol gel auto combustion method with citric acid as a chelating agent and metal to nitrates ration as an 1:3 with maintaining Ph 7. The powder was sintered at temperature 900^o for 6 hours to get a stable product of strontium hexagonal ferrite. After sintering the powder grounded into fine powder and pressed in to pellets by using manual Hydraulic pellet press capacity 1-5 Ton. The dielectric properties studied using LCR meter with varying frequency at room temperature. It was observed that as the frequency increases dielectric constant decreases.

Keywords- Ferrite, sol gel method, Hexaferrite, Dielectric properties.

INTRODUCTION:

From past few decades researcher are interested in synthesis of mixed ferrite with doping of various rare earth elements with varying composition and obtained a remarkable change in its properties which a useful in various instrument. The M-type hexaferites were discovered in 1950 and gaining technological importance due to its properties. It is used in microwave devices, micro strip antennas, radar, memory core etc. They are widely investigated due to its unique properties like excellent chemical stability, high electrical resistivity; high coercivity, high Curie temperature and low production cost compared to other rare earth compounds [1-4]. The structure of strontium hexaferrite composed of S i.e spinel and R i.e. hexagonal block. These block overlapped cubically and hexagonally giving rise to unit cell formula SRS*R*, Where * denotes the rotation of block through 180^o around the c axis. The unit cell is magnetoplumbite crystal structure having space group P63/mmc and 64 ions per unit cell. These 64 ions made from, 38 numbers of oxygen ions, two barium ions and 24 Fe^{3+}

ions. The 24 Fe^{3+} ions distributed over five distinct sites i.e. 12k, 2a, $4f_2$ octahedral site, $4f_1$ tetrahedral and 2b trigonal pyramidal site [5-7]. The various iron sites and relative orientation of their spin moments are responsible for useful properties. Fe^{3+} ions at 2a, 2b, and 12k sites possess spin up while at $4f_1$ and $4f_2$ possess spin down. The doping at Fe^{3+} site leads to changes in structural and electrical properties.

The thrust of researcher to make useful materiel drives synthesis of various magnetic materials with doping of different magnetic, nonmagnetic elements at Sr or Fe site. Topkaya etal [8] found that substitution of yttrium cation improves coercivity and Chen etal [9] discovered a decrease in saturation magnetization as aluminium cation substitution increases. The lattice parameter and dielectric properties were controlled by synthesis methods, sintering temperature and amount of doping at Sr and Fe site. There are various methods used for synthesis of hexaferrite like hydrothermal process [9], solid state reaction [10], sol gel method [11, 12], microwave adsorption method [13], coprecipitation method [14] etc. An attempt has been made to understand the dielectric properties of Co-Dy substituted strontium hexagonal ferrite.

1. EXPERIMENTAL TECHNIQUES:

Sol gel method is employed to synthesize a strontium hexaferrite with chemical formula $SrCo_xDyFe_{11-x}O_{19}$ for x=0.00, 0.25, 0.50, 0.75 and 1. High purity (> 99%) (Sigma-aldrich) Strontium nitrate ($Sr(NO_3)_2.6H_2O$), Cobalt nitrate ($Co(NO_3)_3.6H_2O$), Dysprosium Nitrate ($Dy(NO_3)_3.9H_2O$) and Ferric nitrate ($Fe(NO_3)_3.9H_2O$) with citric acid ($C_6H_8O_7.H_2O$) were taken as starting materials for the synthesis. All the starting materials were mixed in desired stoichiometric amount in sufficient amount of distilled water. The whole mixture is then placed on hot plate with magnetic stirrer. The mixture was continually stirred at constant temperature of 90^{o}C and liquid ammonia was added slowly in order to maintain the Ph a constant value 7. After continuously stirring and heating at 90^{o}C for 2-3 hours the mixture become viscous and sol was formed and after some time it converts into dried gel, by the process of self -ignition the dried gel was burnt and a fine ash was obtained. The burnt ash is grounded for two hours and then subjected to final sintering at 900^{o}C for 6 hours. After final sintering the powders were again grinded for two hours to obtain the fine particles of the final products.

2. CHARACTERIZATION

The dielectric properties studied as a function of frequency using LCR meter.

3. DIELECTRIC PROPERTIES:

3.1 Results and discussion

The electrostatic energy stored by a material per unit volume is called dielectric constant. Fig.1 shoes the dielectric behaviour of dielectric constant with varying frequency at room temperature. The dielectric constant depends on the doping content as well as external applied frequency. The measurements of dielectric properties were carried out with change in frequency at room temperature. The values of capacitance were noted directly on LCR-Q meter with increase in frequency.

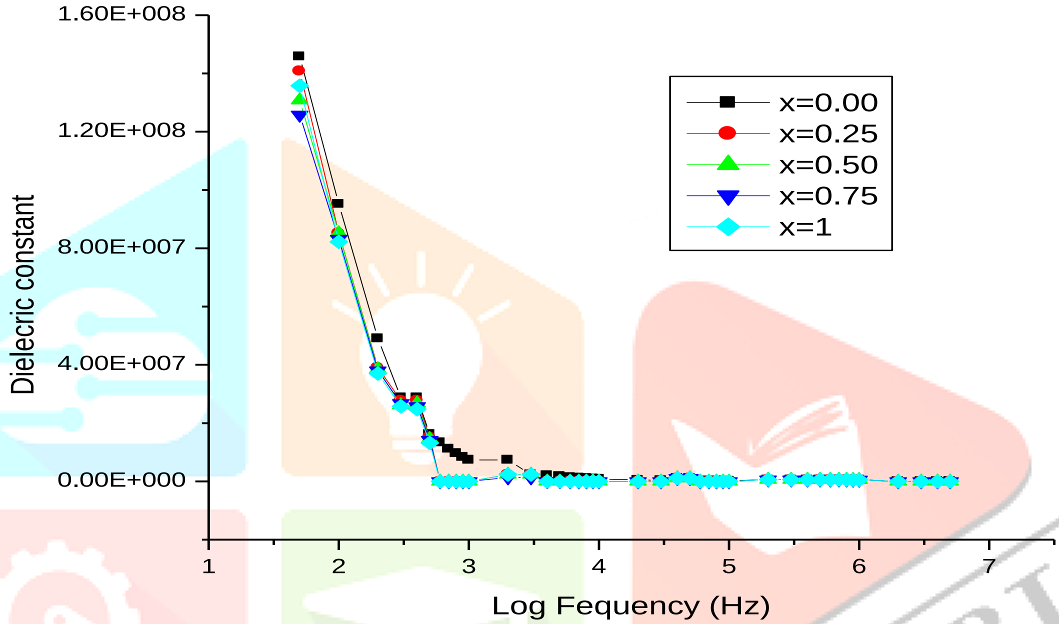

Fig. 1. Variation of Dielectric constant with frequency for $SrCe_xDyFe_{11}O_{19}$ x=0.00, 0.25, 0.50, 0.75,1

The sample in the form of pellets was used. The vales of dielectric constants are calculated by using the relation.

$$\varepsilon' = \frac{CA}{d\varepsilon_o} \qquad 3.1$$

Where C is capacitance, A is area, d is thickness of pellets, ε_o is permittivity of free space.

The calculated dielectric constant values variation with frequency is shown in Fig.1. It is observed that the dielectric constant deceases sharply with increase in frequency and possess a constant value beyond certain frequency. This is a common behaviour of ferromagnetic material and also observed by other researcher [15-17]. The dielectric dispersion present a lower frequency side is due to Maxwell-Wagner type interfacial polarisation well in agreement with the Koops phonological theory [18, 19]. This model explains that the dielectric material with heterogeneous structure can be considered as a structure consisting of well conducing grains separated by a highly resistive thin layer. In this case the applied voltage on the sample drops mainly across the grain boundaries and space charge polarisation is created the grain boundaries. The space charge polarisation determined by the available free charges on grain boundaries and grain boundaries are predominant at low frequency. The thinner is the grain boundary higher the dielectric constant.

As frequency increases and dielectric constant attains a constant value due to a fact that beyond a certain frequency of field, the electron exchange between Fe^{3+}- Fe^{2+} cannot follow alternating external field. The dielectric constant i.e. relative permittivity of a material is very stable in high frequency region hence this material is suitable for a stable high frequency application in a wide frequency range.

4. CONCLUSION

The hexagonal strontium ferrite synthesize successfully by sol gel autocombution method. The pellet was formed using sample powder to measure dielectric properties with varying frequency at room temperature. It was viewed that the dielectric constant with changing frequency have high values at low frequency due to presence of various defects and it becomes stable as the frequency of external field increases due to unable to follow the high frequency field.

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