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FREQUENCY DEPENDENCE DIELECTRIC PROPERTIES OF $NiFe_2O_4$ +$KNbO_3$ COMPOSITE PREPARED BY SOLID STATE REACTION TECHNIQUE.

U. B. Dindore , Suresh T. Alone and K. M. Jadhav

Adarsh Mahavidyalaya, Omerga, Osmanabad, (M S) India
Assistant Professor & Head, Department of Physics, Rajarshi Shahi A. S. & C. College Pathri Phulambri, Aurangabad(M S)
Department of Physics, Dr. B. A. Marathwada University, Aurangabad (M S), India

Abstract:-Magneto-electric composites namely (1-x)$NiFe_2O_4$ + (x)$KNbO_3$ (x =0.0, 0.2, 0.4, 0.6, 0.8, 1.0) were prepared by solid state reaction method. The dielectric measurement were performed using LCR meter bridge the capacitance C of the sample was measured for the varying frequency range 20 Hz - 1MHz at room temperature. . The dielectric constant (ε') decreases exponentially with frequency. The dielectric constant decreases with increase in frequency showing dispersion in the lower frequency range. Dielectric loss (ε") and dielectric loss tangent also (tan δ) decreases with increase in frequency and shows similar behaviour

Keywords: Composite, Dielectric property,

INTRODUCTION:

The ferroelectric material with perovskite structure ABO_3 are great interest in modern technology they can be used for memory devices, light modulators for optical communication systems or piezoelectric detector of radiations. Amongst such perovskite oxides $KNbO_3$ presents attractive properties for electro-optical operations. $KNbO_3$ has a paraelectric cubic phase with its Curie point of 4350C. The ferrite-ferroelectric composites can be prepared by ceramic method [1-3] or by wet chemical methods like sol-gel method [4] or Solid state reaction route [5]. The ceramic method for the preparation of composites was preferred over the other methods because ceramic method is easier and cheaper than other methods. Further the preparation of composites by ceramic method offer certain advantages such as choice of mole ratio of constituent phases, free choice of sintering temperature etc. [6,7].

In the present paper, an attempt is made to study the dielectric properties of nickel ferrites ($NiFe_2O_4$) and potassium niobate ($KNbO_3$) composite with varying composition by Solid state reaction method.

EXPERIMENTAL PROCEDURES:

The spinel ferrite '$NiFe_2O_4$' was prepared by standard ceramic technique using AR grade oxides of NiO and Fe_2O_3 supplied by s. d. fine. The oxide powders are mixed in stoichiometric proportions and ground for about 3-4 hours in an agate mortar and pestle. The mixed fine powder is pre-sintered at 900^0C for 12 hours. The sintered powder is again reground and finally sintered at 1075^0C for 12 hours. The prepared sample of $NiFe_2O_4$ was characterized by X-ray diffraction technique and it is revealed from X-ray analysis that the prepared sample possesses single phase cubic spinel structure. The potassium Niobate ($KNbO_3$) was prepared through normal solid state reaction taking potassium carbonate (K_2CO_3), Niobium pent-oxide (Nb_2O_5) in molar proportion. The mixed powder of potassium carbonate (K_2CO_3) and niobium pent-oxide (Nb_2O_5) was ground using agate in mortar and pestle and presintered at 900^0 C. In the final sintering the material was held at 1050^0C for 12 hours. The sintered samples were allowed to cool to room temperature. The analysis of XRD pattern of $KNbO_3$ revealed the formation of single phase tetragonal compound. ME composites with compositions (1-x) $NiFe_2O_4$+(x) $KNbO_3$ with (x = 0.0, 0.2, 0.4, 0.6, 0.8and 1 mole %) was prepared by solid state reaction method. Fine powders of nickel ferrite ($NiFe_2O_4$) and potassium niobate ($KNbO_3$) were mixed thoroughly in molar proportion and ground for about 3 hours, 2 wt. % polyvinyl alcohol was as a binder in the mixed powders. The mixed powder is then press into pellets of thickness of around 2-3 mm and diameter 10mm using a hydraulic press. A pressure of 5 ton/cm^2 was applied. The palletized samples were sintered at 1050^o C for 24 hours in a programmable furnace. The pellets were lastly furnace cooled to room temperature.

The measurements were performed on circular pellet of 10 mm diameter and 2 mm thickness using two-probe method.

The dielectric constant (ε') is calculated using the following relation

$$\varepsilon' = \frac{Cd}{\varepsilon_0 A} \qquad \ldots\ldots(1)$$

where, C is capacitance, d is thickness of pellet, ε_0 is permittivity of the free space, A is cross sectional The dielectric measurement were performed using LCR meter bridge (model HP 4284A) the capacitance C of the sample was measured for the varying frequency range 20 Hz -1MHz at room temperature. area of pellet. The dielectric loss () was calculated using the relation

$$\varepsilon'' = \frac{1}{2\pi \cdot 1000 \cdot \varepsilon_0} \sigma \qquad \ldots\ldots(2)$$

where, σ is a.c. conductivity, The dielectric loss tangent (tan δ) was calculated using the relation.

$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} \qquad \ldots\ldots(3)$$

3. RESULT AND DISCUSSION:

The dielectric properties of ME composites of (1-x) $NiFe_2O_4$+(x) $KNbO_3$ are investigated as a function of frequency using LCR-Q meter. Fig. 1 shows the variation of dielectric constant (ε') as a function of frequency for all the compositions recorded at room temperature. The dielectric constant (ε') decreases exponentially with frequency. The dielectric constant decreases with increase in frequency showing dispersion in the lower frequency range. It attains a constant value independent of frequency thereafter. Dielectric constant falls rapidly in the beginning for the compositions having higher values of dielectric constant indicating that dispersion is large in compositions with large values of (ε') in comparison with those having smaller values of (ε') All the samples reveal dispersion due to Maxwell-Wagner [8, 9] type interfacial polarization in agreement with Koops phenomenological theory [10]. The high values of dielectric constant observed at lower frequencies are explained on the basis of space charge polarization due to inhomogeneous dielectric structure. The inhomogenities in the present system are impurities, porosity and grain structure. However in case of composites, the high values of (ε') is ascribed to the fact that ferroelectric regions are surrounded by non-ferroelectric regions similar to that in case of relaxor ferroelectric materials [11]. This again gives rise to interfacial polarization. Fig. 3 shows the variation of tan δ with frequency for all the composites, which shows a similar dispersion as that of (ε'). The dielectric constant (ε') shows high values at low frequency where as it shows minimum values at higher frequency. The dielectric constant (ε') varies with composition 'x' at low frequency where as it is almost constant for all composition at higher frequency. The behaviour of dielectric constant (ε') is similar to other composites reported in the literature [11, 12]. Similar trend of the values of dielectric loss (ε'') and dielectric loss tangent (tan δ) was observed. The dielectric loss (ε'') increases fast at lower frequency compared to that of higher frequency (1MHz). The dielectric loss tangent (tan δ) also increases very fast at lower frequency compared to the values of dielectric loss tangent (tan δ) for high frequency. The dielectric loss (ε'') and dielectric loss tangent also (tan δ) decreases with increase in frequency and shows similar behaviour to that of dielectric constant as shown in Fig. 2,3.

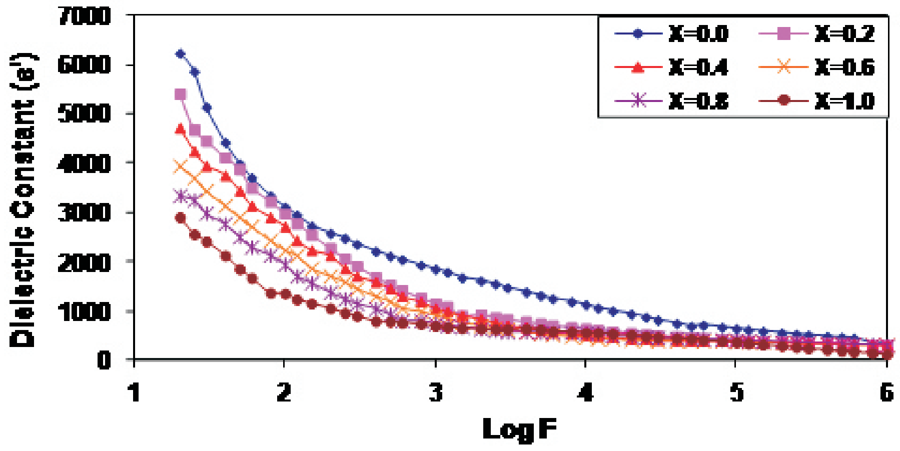

Fig.1 Variation of dielectric constant (ε') with frequency (F) for (1-x) $NiFe_2O_4$ +(x) $KNbO_3$

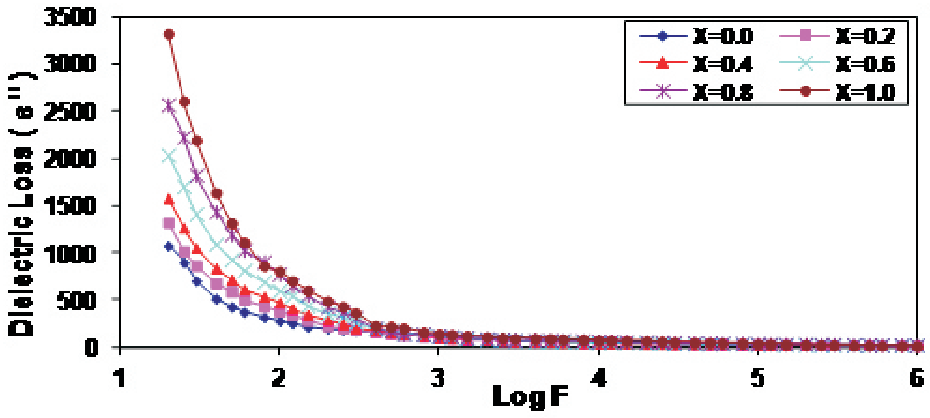

Fig.2 Variation of dielectric loss (ε”) with frequency (F) for (1-x) $NiFe_2O_4$ +(x) $KNbO_3$

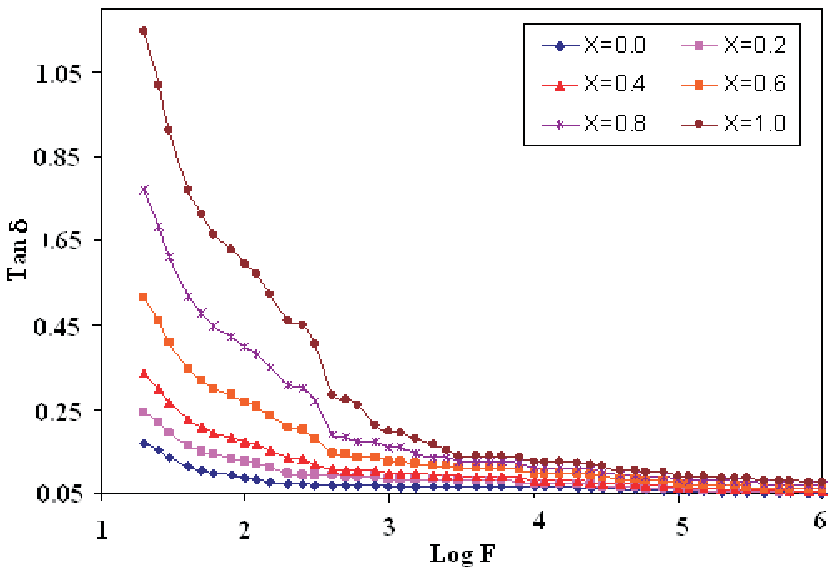

Fig. 3 Variation of dielectric loss tangent (tan δ) with frequency (F) for (1-x) $NiFe_2O_4$+(x) $KNbO_3$

4. CONCLUSIONS:

The composite system $NiFe_2O_4$ +$KNbO_3$ was successfully synthesized by solid state reaction method. The dielectric constant (ε'), dielectric loss (ε") and dielectric loss tangent (tan δ) decreases with increase in frequency and shows similar behaviour.

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Suresh T. Alone
Assistant Professor & Head, Department of Physics,Rajarshi Shahi A. S. & C. College Pathri Phulambri, Aurangabad(M S) India