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DIELECTRIC PROPERTIES OF $Co_{.6}Zn_{.4}Mn_xFe_{2-x}O_4$ SPINEL FERRITE

A I ELSHORA, G A GABALLA, A S SOUD, M A HENAISH AND S A EI-ATTAR

Physics Department, Faculty of Science, Tanta University, Tanta, Egypt

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Dielectric constant of $Co_{.6}Zn_{.4}Mn_xFe_{2-x}O_4$ (x = 0.0, 0.1, 0.2, 0.3, 0.4 and 0.5) as a function of temperature and composition at a frequency of 1 KHz are reported. The results show that there is a correlation between the conduction mechanism and the dielectric behaviour of the samples. The estimated polarization and the dielectric loss as a function of manganese addition x are presented.

Key Words: Dielectric Properties; Microwave; Radio Frequency

Introduction

Ferrites have vast applications from microwave to radio frequency. So it is important to study their dielectric behaviour at different frequencies[1]. The dielectric properties of ferrites are dependent on several factors including the method of preparation and the sintering temperature. In our previous work[2] we attempted to explain the effect of manganese addition on some physical properties of $Co_{.6}Zn_{.4}Mn_xFe_{2-x}O_4$ system such as lattice constant, X-ray density, bulk density, porosity, magnetic susceptibility and dc electrical conductivity. In this paper we represent and study the effect of manganese addition on the dielectric behaviour of Co-Zn ferrite.

Experimental

A series of ferrite samples of composition $Co_{.6}Zn_{.4}Mn_xFe_{2-x}O_4$ (x = 0.0, 0.1, 0.2, 0.3, 0.4 and 0.5) were prepared by means of usual ceramic technique. The samples were pressed to a cylindrical shape (disks), sintered at 1300°C for four hours and slowly cooled to room temperature. X-ray diffraction showed that the samples were cubic spinels. The dielectric constant and dielectric loss of the prepared samples were measured at 1 KHz and 1 volt by using R.L.C. bridge of type BM 591.

Results and Discussion

Temperature Dependence of Dielectric Constant

The variation of the dielectric constant ε' against temperature are shown in Fig. 1. It can be seen from this figure that ε' increases slowly with temperature up to 150°C and above that temperature it is increasing rapidly. The conductivity of the samples is increasing slowly at lower temperatures and rapidly

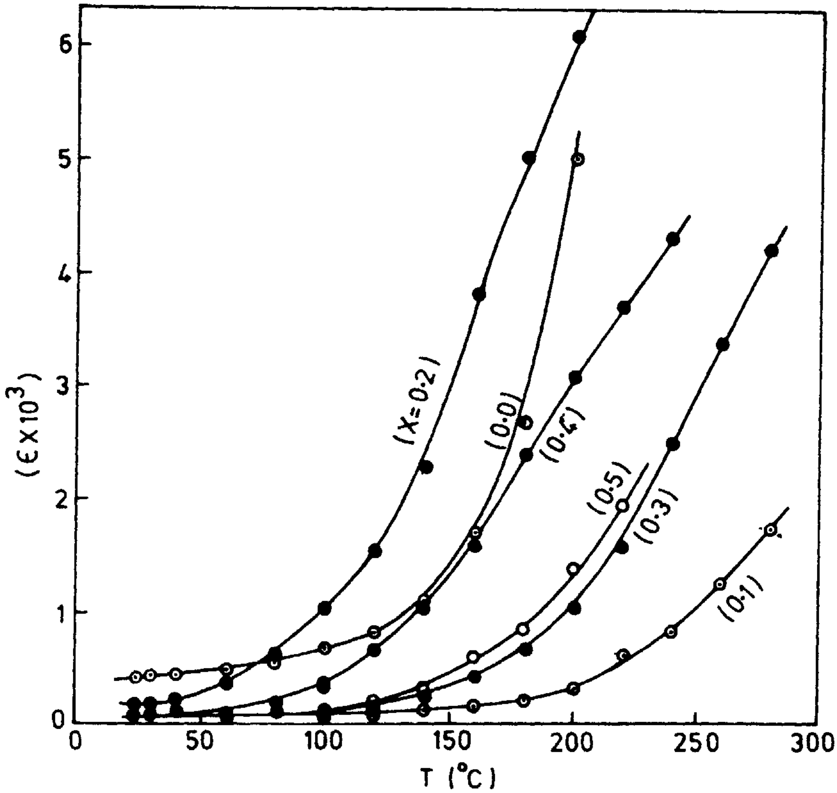

Fig 1 Dielectric constant ε as a function of temperature for different Mn composition X

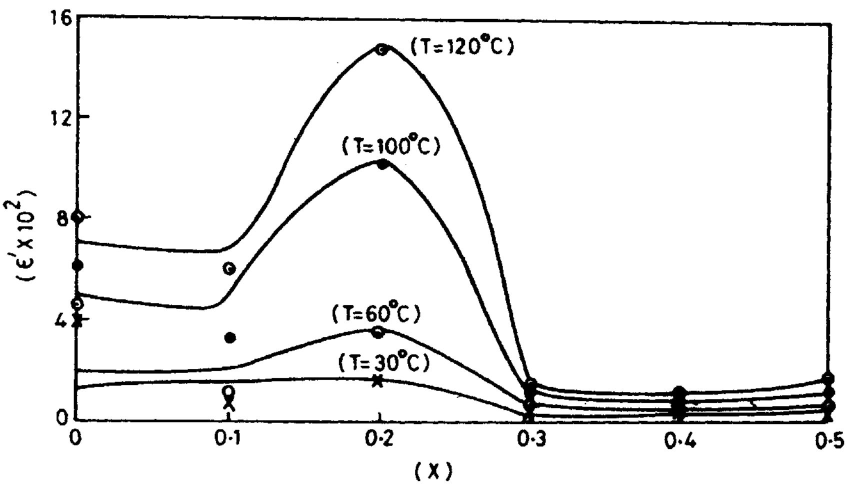

Fig 2 Dielectric constant ε as a function of Mn composition X, at a temperature of 30, 60, 100 and 120 °C

at higher temperatures[3,4]. Thus the samples are showing higher conductivity above 150°C and hence ε′ increased rapidly above this temperature. The presence of cobalt in the octahedral sites, the spinel favours a conduction mechanism $Co^{2+} + Fe^{3+} \leftrightharpoons Co^{3+} + Fe^{2+}$ which explains the predominant conduction mechanism in Co-Zn ferrites[4]. The presence of Mn^{4+} can also influence the conductivity of the ferrite material. The behaviour of our results is similar to that of previous work[5].

Composition Dependence of Dielectric Constant

The variation of the dielectric constant, ε', with the manganese additions is studied at 30, 60, 80 and 120°C and is shown in Fig. 2. It can be seen that there is a pronounced increase of the dielectric constant occurred at $x = 0.2$. This behaviour may be discussed on the basis that Mn^{4+} inter the lattice substitutionally in the B sites. A hopping of electrons between Fe^{3+} and Mn^{4+} will happen. Furthermore exchange jumping electrons occurred between Fe^{3+} Fe^{2+} over the octahedral sites of n-type ferrite. This mechanism increase the ferrous ions at B sites which are the dominant role for increasing the polarization at the surface of the samples containing $x = 0.2$ for $x > 0.2$ the decrease of the dielectric constant is attributed to the transformation of some Mn^{4+} ions to A sites instead of B sites, leading to decrease the number of ferrous ions at the B sites. This behaviour decrease the polarization at the B sites and hence the dielectric constant. Figs 2&3 indicate that the behaviour of the dielectric polarization with Mn additions confirms the behaviour of the dielectric constant. In conclusion the number of ferrous ions on the octahedral sites plats a dominant role in the mechanisms of the conduction and dielectric polarization as in the previous work[2,6].

Variation of the Dielectric Loss with Composition

The effect of manganese addition x on the dielectric loss of $Co_{.6}Zn_{.4}$ ferrites at room temperature 30°C is illustrated in Fig. 4. It can be seen that the maximum increase of the dielectric loss occurred at $x = 0.2$. This behaviour may be discussed on the basis of the dielectric polarization. For higher dielectric loss, the hopping frequency is smaller and this led to increasing in the relaxa-

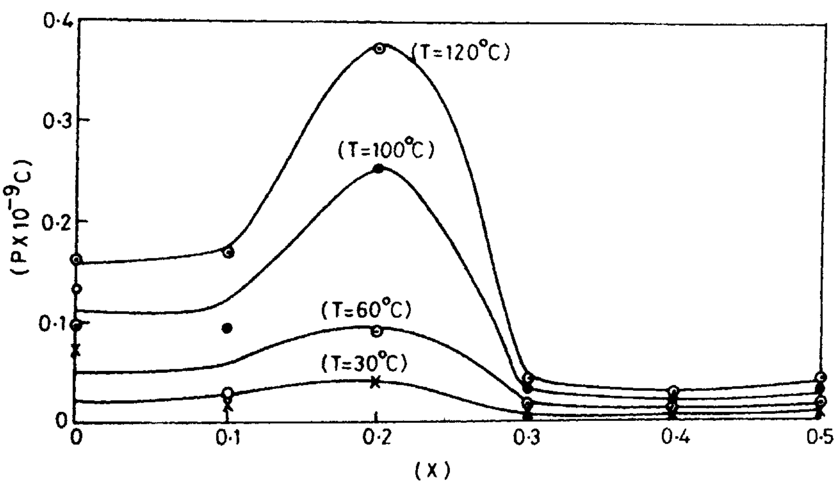

Fig 3 The estimated polarization P as a function of Mn composition X

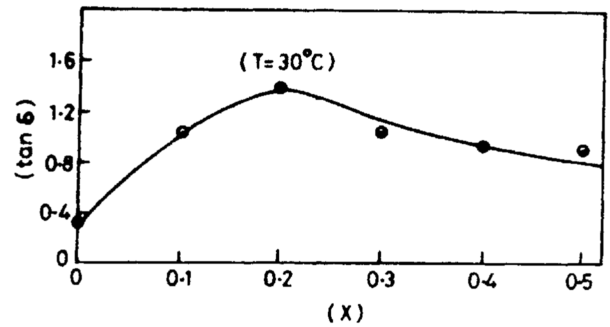

Fig 4 Dielectric loss as a function of Mn composition X.

tion time, as a result the dielectric loss is increased. For $x > 0.2$ the decrease of the dielectric loss is attributed to that the hopping frequency is not equal to the external electric field (1 KHz). This difference in the frequency decrease the dielectric loss.

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