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ARTICLE

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RELAXATION PROCESS OF FE-DOPED V_2O_5•MOO_3•CDO•ZNO GLASSY NANOCOMPOSITES

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*In this study, we have developed a Fe-doped glassy system comprising xFe·(1-x)·(0.3*V_2O_5*·0.2*MoO_3*·0.4CdO·0.1ZnO) where x = 0.0, 0.05, and 0.10 using melt-quenching method. This study mainly focuses on the electrical relaxation process of Fe-doped glass nanocomposites. Conductivity relaxation frequency (*τ_c*) has been computed from the frequency dependence of* Z''*plot. It has also been observed that the conductivity relaxation process is a thermally activated behaviour of* τ*. The relaxation time (*τ*) has decreased with increasing the Fe concentration.*

Introduction

Dielectric properties of nano-glassy nanocomposites have drawn attention due to their potential use in various device applications in recent years[1,2]. Mainly the dielectrics in glassy systems have been used as insulators in the electrical field and as an ingredient of capacitance in electronic circuits[1]. In solid-state electronics, dielectric characteristics of the glassy nanocomposites have also been used[3]. Transition metal oxides (TMO) based nanocomposite glassy systems have gained popular interest due to their surprising demand in the field of electrical and optoelectronic devices [4–6].

Analysis of complex impedance and estimation relaxation of glassy composites system have been discussed in various literature[7-9]. The temperature, as well as frequency-dependent electrical relaxation processes of Fe-doped systems,have also been investigated[10-11].

However, it would be more attractive when Fe is doped in the V_2O_5-MoO_3-CdO-ZnO glassy system. In this present study, the main objective is to investigate the electric relaxation process of the Fe-doped glassy nanocomposite system.

Experimental Procedure

Glass composites xFe·(1-x)·(0.3V_2O_5·0.2MoO_3·0.4 CdO·0.1ZnO) where, x = 0.2, 0.3, and 0.4 preparation was performed according to a literature-reported method[6]. The complex impedance measurements of all as-prepared samples (thickness ~1mm) have been execute dusing a programmable automatic LCR tester (HIOKI, Model No. 3532–50) at various temperatures in the frequency range of 42 Hz to 5 MHz.

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Results and Discussion:

In the present investigation, the relaxation process of as-prepared glassy samples has been analyzed. This relaxation process of the present glassy system has been approached as Debye-type relaxation[7, 8]. That is calculated using the following necessary condition: $\omega_{max} \times \tau = 1$, where τ is relaxation time[7, 8]. ω_{max} are estimated from the frequency dependence of Z'' plot (Fig. 1 (c)). Relaxation data of present glass nanocomposites x = 0, 0.05, and 0.1 have been evaluated in the framework of the complex impedance formalism at different temperatures[7]. The complex impedance plots of the as-prepared glassy sample, x = 0.1 presented in Fig. 1(a) temperature ranges between 413K to 513K.

It has been cleared from Fig. 1 (a), at the lower temperature of 413K, the radius of the semi-circular arc is found maximum (when x = 0.1). It has been also observed from Figure 1(a) that the radius of the semi-circular arc decreases with increasing temperature. From Fig. 1 (b), the radius of the semi-circular arc is found minimum at a higher temperature of 633K. Uniform variation of semi-circular arc has been computed for other as-prepared samples (x=0, 0.05). Here, the Cole-Cole plot (complex impedance plots) has been used asa powerful tool to observe a single or many more relaxation process materials with proportionate magnitudes[12,13]. In Fig. 1 (d), the frequency dependence of the Z'' plot has been shown at different temperatures of a particular system (x = 0.1). Relaxation time (τ) with

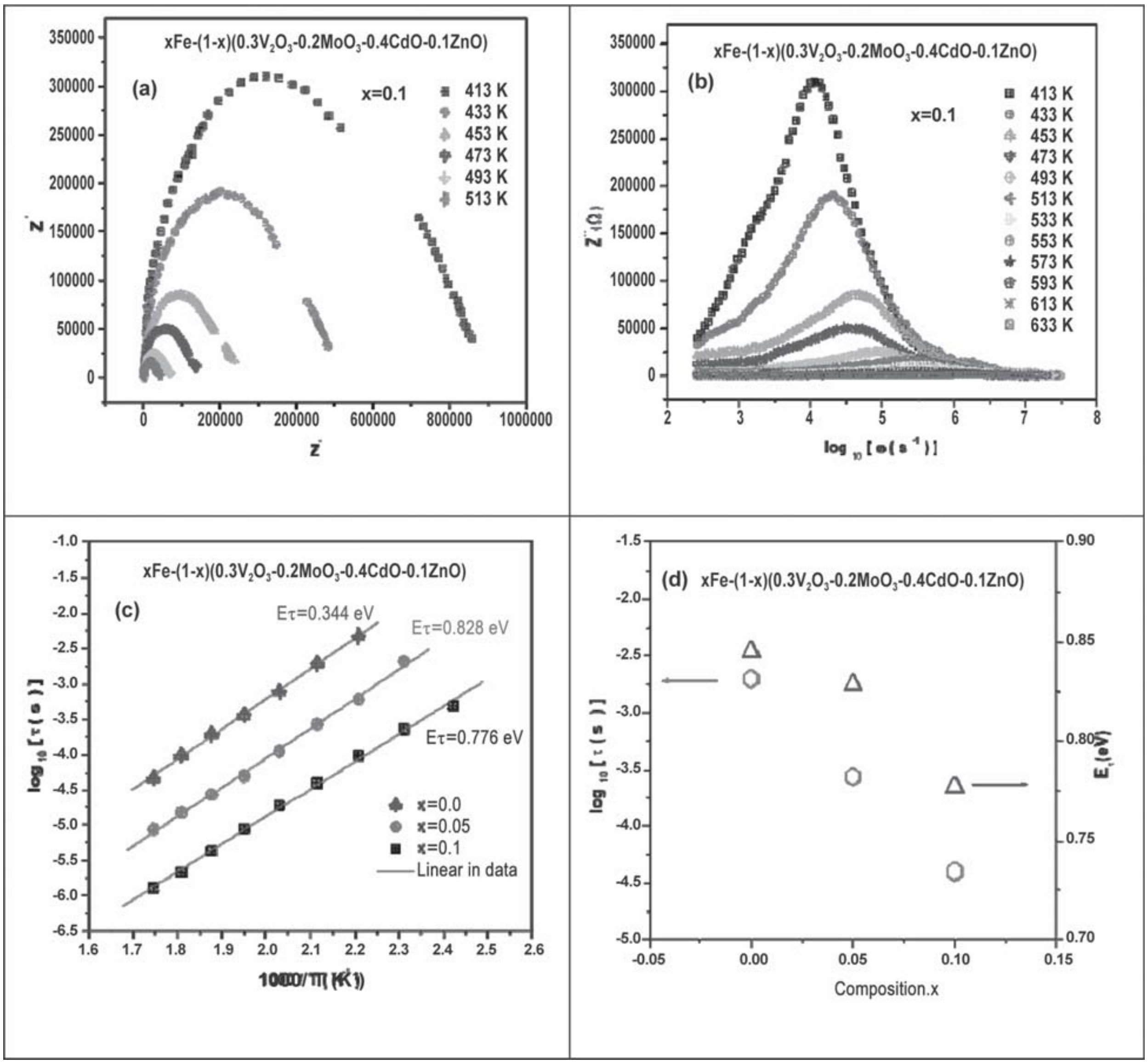

Fig. 1 (a) Cole-Cole plot of resistivity of the present glassy system (Where x = 0.1) (T = 413K to 513K) (b) Frequency dependence of $Z^{//}$ at various temperatures of the present glassy system(Where x = 0.1) (c) Relaxation time (τ) with reciprocal temperature for different compositions. (d) Variation of relaxation time (τ) at 473 K and activation energy (E_τ) corresponding to composition, x.

reciprocal temperature (1000/T) plot has been shown in Fig. 1 (d) for all as-prepared glassy samples (x=0, 0.05, and 0.1) with the help of debye type relaxation condition. Behaviour of relaxation time (τ) has been observed the thermally activated. Values of the relaxation time (τ) have been foundin decreasing order with increasing temperature which is depicted in Fig 1 (d), which recommended the semiconducting nature[12]. The theoretical relaxation time can be computed using the following relation:

$$\tau = \tau_0 \exp\left(-\frac{E_\tau}{k_B \tau}\right)$$

where τ_0 is a pre-exponential factor, K_B is the Boltzmann constant, and T is the absolute temperature.The value of activation energy (E_τ) associated with the relaxation process has been computed from the slopes of the best-fitted straight lines as depicted in Fig. 1 (c) estimated values of activation energy (E_τ) have been presented in Fig. 1(d). In Fig. (d), relaxation time (τ) at fixed temperature 473 K and corresponding to composition, x has been also incorporated. It has been also clear that the values of relaxation time (τ) as well as activation energy (E_τ)have been decreased with increasing the concentration of Fe. That is validated by the conductivity data[7, 8].

Conclusion

A study of electrical complex impedance and relaxation process of the present glassy system on the effect of Fe-doped glass-nanocomposites in the various temperature ranges and frequency ranges 42Hz - 5MHz reveals the following conclusions:

1. At a lower temperature of 413K, the radius of the semi-circular arc is found maximum and at a higher temperature of 633K, the semi-circular arc is found minimum. The radius of the semi-circular arc decreases with increasing temperature. The conductivity relaxation time (τ) gradually decreases with increasing temperature.
2. As the concentration of Fe increases, relaxation time (τ) as well as activation energy (E_τ) decreases and at fixed temperature, conductivity relaxation frequency increases with Fe content in the glass matrix, which suggests lower conductivity relaxation time. ❒

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