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Conduction Mechanism And Dielectric Loss In V_2O_5–P_2O_5–B_2O_3–Ceo_2 Glasses

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ABSTRACT

The samples of composition $60V_2O_5$–$5P_2O_5$–(35-x) B_2O_3–xCeO_2, x = 1, 2, 3, 4 and 5 mol % were prepared by melt-quench method. The prepared samples were characterized by X-ray diffraction. The x-ray powder diffraction patterns at room temperature show that all samples are amorphous in nature. The AC conductivity is analyzed by different processes, which can be attributed to the correlated barrier hopping (CBH) model amongst the several models. With increasing temperature the dielectric loss peak shifts to higher frequency. This dependence of dielectric loss on frequency is related with losses by conduction.

Keywords: melt-quench; CBH model; dielectric loss.

I. INTRODUCTION

Vanadium pentoxide is known to have a structure composed of VO_5 pyramids. The vanadates based glasses shows semiconducting behaviour due to electron hopping between V^{4+} and V^{5+} ions [1]. Various vanadium ions doped glasses have been investigated; most of them are restricted to structural studies. Hence, there is a scope to investigate the influence of vanadium ions alkaline earth borate glasses, through impedance study [2]. The rare earth and transition metal containing glasses have been widely studied using structural and optical spectroscopy due to their several applications.

Some of the possible applications are optical amplifiers in telecommunication, phosphorescence materials and electrochemical batteries [3]. Rare earth metal ions when added to borate act as network modifiers and change the properties of glasses. In rare earth metals, cerium oxide doped glasses have been studied by many researchers because of their applications as biosensor [4], solid oxide fuel cells [5], corrosion protection [6], photo luminescent material [7] and also used in tunable solid state lasers operating in the UV, violet and blue regions [8]. Inspiring from the above discussion, we prepared glass system $60V_2O_5$–$5P_2O_5$–(35-x) B_2O_3–xCeO_2, x = 1, 2, 3, 4 and 5 mol % to analysed Conduction Mechanism and dielectric loss. The conductivity was determined using impedance spectroscopy of these glasses at different temperature. The prepared samples were characterized by X-ray diffraction (XRD).

II. EXPERIMENTAL

The glass samples of composition $60V_2O_5$–$5P_2O_5$–(35-x) B_2O_3–xCeO_2, x = 1, 2, 3, 4 and 5 mol %, were prepared by a conventional melt-quenching method. AR grade (SD fine, india) chemicals were weighed and mixed together. This mixture was homogenized and melted in silica crucible at 900 °C for 3 h. After melting, the mixture was poured out onto a nonmagnetic stainless steel substrate and pressed with another stainless steel substrate. In this way, quenching was achieved by rapid cooling of molten mixture to substrate temperature. To avoid internal strains, the samples were annealed at 200 ºC for 1 h and then cooled slowly to room temperature.
XRD analysis of the samples was carried out using CuKα radiation (1.54 A°) by RIGAKU X-Ray diffractometer in the 2θ range of 10–70°. The temperature dependence of electrical conductivity σ and dielectric constant ε′ were measured using LCR meter, Agilent Technology, Singapore. The measurements were

performed in a frequency region of 20 Hz to 1MHz and a temperature range of 303–473 K.

III. RESULTS AND DISCUSSION

3.1 XRD analysis

Figure 1 depicts the XRD patterns of the $60V_2O_5$–$5P_2O_5$–(35-x) B_2O_3–$xCeO_2$, x = 1, 2, 3, 4 and 5 mol %, a broad diffused peak and absence of well defined peaks clearly pointed out the formation of glass. The amorphous hallow appears at the same 2θ-position.

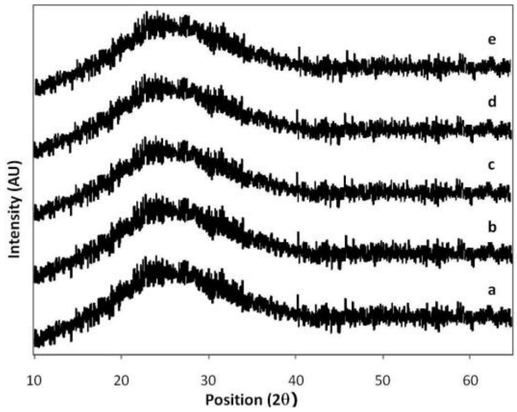

Figure 1. XRD of $60V_2O_5$–$5P_2O_5$–(35-x) B_2O_3–$xCeO_2$ for (a) x=1 mol%, (b) x=2 mol%, (c) x=3 mol%, (d) x=4 mol% and (e) x=5 mol%.

3.2 Dielectric loss measurement

The dielectric loss (tanδ) shows that the phase difference is due to the loss of energy within the sample at a definite frequency. The frequency dependence of tanδ at different temperatures is shown in Figure2. At lower frequencies, tanδ increases with increase in frequency. This may be due to rapid response of active component than its reactive component. With increasing temperature the tanδ peak shifts to higher frequency.

This dependence of tanδ on frequency is related with losses by conduction [3]. The observed dielectric loss may be due to two reasons: (i) the thermal excitation generates the Debye-type freely rotating dipoles and (ii) at higher temperatures, electrons take part in conduction scattered by phonon [9].

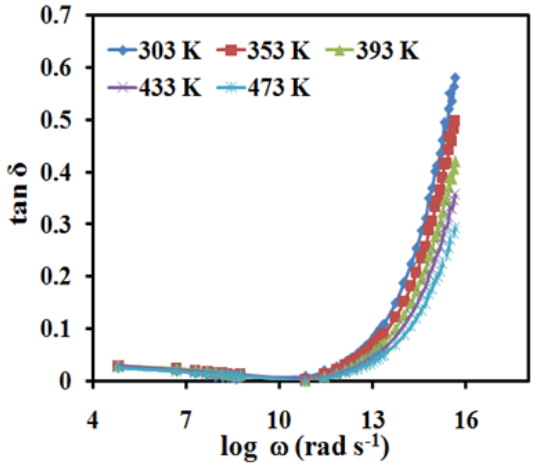

Figure 2. Plot of dielectric loss vs. log (ω)

3.3 Theory Used for the Investigation of the Conduction Mechanism

In order to find the conduction mechanism of the AC conductivity, we suggest the some suitable model for the conduction mechanism in consideration of the several theoretical models with "s" comportment. These different models are: (i) The overlapping-large polaron tunneling (OLPT) model [10]. (ii) The non-overlapping small polaron tunneling (NSPT) model [11]. (iii) The quantum mechanical tunneling (QMT) model. (iv) The correlated barrier hopping (CBH) model [12]. Figure3 showed the variation of the exponent "s" as a function of temperature. It indicates that the value of "s" decreases with the increasing temperature. This result suggests that the CBH model is the appropriate model to characterize the electrical conduction mechanism in these glass systems.

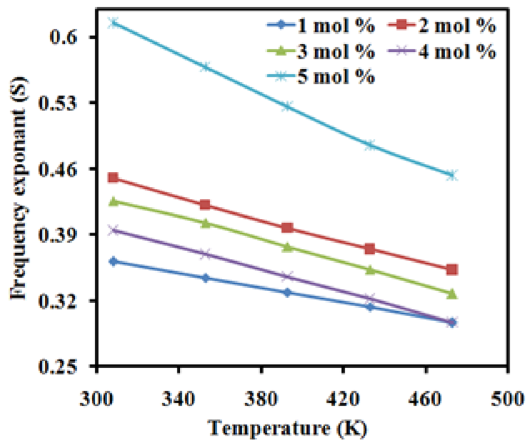

Figure 3. Variation of exponent "s" with temperature.

IV. CONCLUSIONS

The melt-quenching technique is a very simple method for the preparation of conducting glasses. The amorphous nature of glasses was reflected from XRD study. The tanδ peak shifts to higher frequency with increasing temperature. This dependence of tanδ on frequency is related with losses by conduction. The tanδ peak is positioned at low frequency region, where the conductivity is dominated by DC conductivity. The variation of the exponent "s" as a function of temperature indicates that the value of "s" decreases with temperature, which suggests that the CBH model is the appropriate model to characterize the electrical conduction mechanism in these glass systems.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

[1]. R V Barde and S A Waghuley 2013 Ceram. Inter. 39 6303
[2]. M Subhadra and P J Kistaiah 2011 Phys. Chem. A 115 1009
[3]. R V Barde and S A Waghuley, 2015 Bull. Mater. Sci. 38 7.
[4]. A A Ansari, A Kaushik, P R Solanki and B D Malhotra 2008 Electrochem. Com-mun. 10 1246
[5]. H Guo and Y Qiao 2008 Appl. Surf. Sci. 254 1961
[6]. T Murata, M Sato, H Yoshida and K Morinaga 2005 J. Non-Cryst .Solids 351 312
[7]. M Laroche, S Girard, R Moncorge, M Bettinelli, R Abdulsabirov and V Semashko 2003 Opt. Mater. 22 147
[8]. G Pal Singh and D P Singh 2011 Physica B 406 3402
[9]. E.E. Shaishay, F. El-Desouki, I. Shaltout, A.A. Bahgat, 2006 J. Mat. Sci. & Tech. 22 701.
[10]. M. Ben Bechir, K. Karoui, M. Tabellout, K. Guidara, A. Ben Rhaiem 2014 J. Appl. Phy. 115 153708.
[11]. Y. Ben Taher, A. Oueslati, M. Gargouri 2015 Ionics 21 1321.