Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 2(H), pp. 24291-24294, February, 2018

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

STUDY OF STRUCTURAL AND DC ELECTRICAL PROPERTIES OF Sb_2O_3 SUBSTITUTED LEAD VANADATE SEMICONDUCTING GLASS SYSTEM

Brahmananda Rao K K[1]., Ramesh K V[2]* and Tejeswara Rao P[3]

[1]Kendriya Vidyalaya-1, 104 Area, Visakhapatnam
[2]Department of Electronics and Physics, GITAM Institute of Science, GITAM (Deemed to be University), Rushikonda, Visakhapatnam
[3]Department of Physics, GITAM Institute of Technology, GITAM (Deemed to be University), Rushikonda, Visakhapatnam

DOI: http://dx.doi.org/10.24327/ijrsr.2018.0902.1635

ARTICLE INFO

Article History:
Received 15th November, 2017
Received in revised form 25th December, 2017
Accepted 23rd January, 2018
Published online 28th February, 2018

ABSTRACT

DC electrical properties investigations of $xSb_2O_3(50\text{-}x)$ PbO:$50V_2O_5$(X=5, 10, 15 in molar ratio) glasses were carried out using X-ray diffractrometer (XRD), Scanning electron microscopy (SEM), differential scanning calorimetric analysis (DSC) and DC electrical conductivity with two probe techniques. XRD results shown that the Perfect vitrification has been achieved and DTA results have indicated that the substituent Sb_2O_3 is replacing PbO in the glass network in such a way that 1:1 composition and the eutectic nature is maintained. SEM investigations were carried out for the micro structural characterization of V_2O_5 crystal phases. The DC electrical conductivity studies on Sb_2O_3substituted glass systems annealed at 140^0C indicated that the conductivities increased as the concentration of dopant substitution increases

INTRODUCTION

Glasses having transition metal ions (TMIs) such as vanadium or iron ions show a semiconducting behavior. (MottN.F 1967,1968) found that the DC electrical conductivity of semiconducting oxide glasses is due to small polaron hopping from a low valance state to a high valance one of a transition metal ion(TMI) (eg. from V^{4+} to V^{5+}). These glasses have been considered as a new branch in semiconducting glasses because of their wider glass forming region and possible technological applications (Al-Shahrani *et al*, 2003; El-Desoky MM *et al*, 2003; El-Desoky MM *et al*, 2004; Saddeek YB *et al*, 2009). In the last three decades several attempts were made to develop fast ion conducting glasses because of their prospective applications such as high energy density batteries (Takahashi H *et al*, 2010). The physical properties of the leadvanadate glasses can be improved by the addition of metal oxides (Kiran N *et al*, 2011; Kim CE *et al*, 2011). Glasses containing rare earth and transition metal have been widely studied using structural and optical spectroscopy due to their many potential applications, like optical amplifiers in telecommunication (Pisarski WA *et al*, 2005), phosphorescence materials and electrochemical batteries (Qiu J *et al*, 2005).

The aim of the present work is to prepare the glass system xSb_2O_3 (50-x) PbO: $50V_2O_5$(x=5, 10, 15 in molar ratio) to analyze the thermal, microscopic changes and DC electrical properties of the glass samples.

Experimental

A series of glass with the molar formula x Sb_2O_3 (50-x) PbO: 50 V_2O_5 (X=5, 10, 15 in molar ratio) were prepared. Appropriate amounts of reagent grade Sb_2O_3, PbO and V_2O_5 were well mixed and melted in silica crucibles using an electrical furnace at a temperature ranging between 950^0C-1000^0C range, depending on the glass composition. The melt was swirled frequently to insure the homogeneity the melts were quenched on a large stainless-steel block maintained at room temperature (≈30^0C) and constituting of 9mm cylindrical cavities to get samples of cylindrical shape of 2 to 3mm width. The glass samples were annealed at 140^0 C below the glass transition temperature for nearly 2 hours. The samples were washed with an acetone and dried. The glasses were stored in desiccators until required.

Corresponding author:* **Ramesh K V
Department of Electronics and Physics, GITAM Institute of Science, GITAM (Deemed to be University), Rushikonda, Visakhapatnam

RESULTS AND DISCUSSION

The X-ray diffractograms of the present samples are shown in Fig.1. From the plots it is found that all samples exhibiting the amorphous nature. The DTA patterns of these glass systems shown in Fig.2. Values of Glass transition temperature T_g, Crystallization temperature T_c, Melting temperature T_m, and densities of the $xSb_2O_3(50-x)$ PbO: $50V_2O_5$ are given in Table1 and these results suggest that Sb_2O_3 acts as a network modifier where as PbO acts as a network former. As seen in Figure.2 upto x= 15 mole% there is only one endothermic peak corresponding to melting point. This indicates that the substituted samples the eutectic composition upto x=15 mole% is maintained.

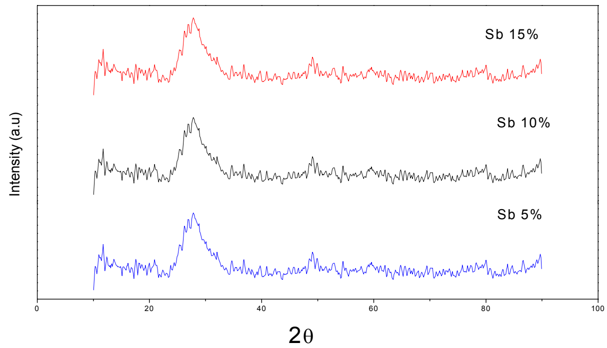


Figure 1 X-Ray diffractograms of $xSb_2O_3(50-x)$ PbO:$50V_2O_5$ (x=5, 10, 15)

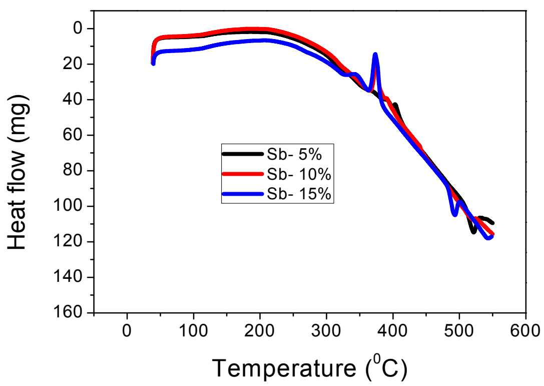
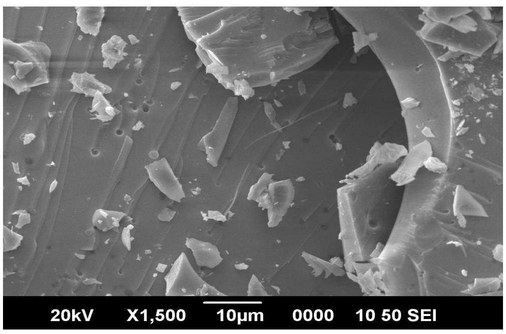
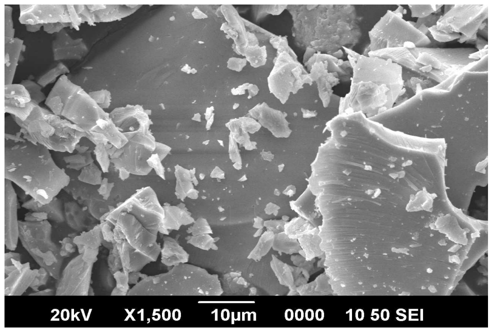


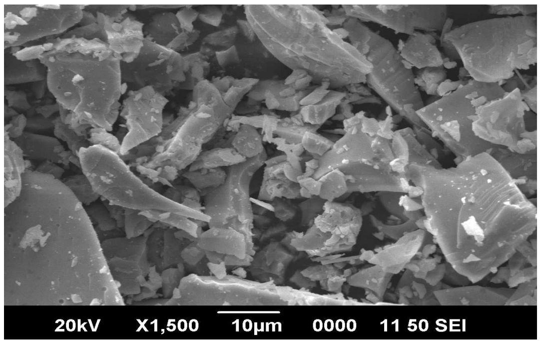
Figure 2 DSC patterns of $xSb_2O_3(50-x)$ PbO:$50V_2O_5$ (x=5, 10, 15).



(a) Sb 5%



(b) Sb 10%



(c) Sb 15%

Figure 3 Microstructure studies of $xSb_2O_3(50-x)$ PbO:$50V_2O_5$(X=5, 10, 15)

Table 1 Values of glass transition temperature T_g, crystallization temperature T_c, melting temperature T_m, and densities of the $xSb_2O_3(50-x)$ PbO: $50V_2O_5$

Substitution of Sb_2O_3 (x)	T_g	T_C	T_m
5%	114	404	505
10%	94	374	502
15%	88	375	492

The SEM photographs are shown in Fig.3, from the SEM photographs of present samples it is observedthere is a small change in microstructure as the dopant concentration increases. The reciprocal temperature dependence of the DC conductivity for samples annealed at 140^0C is shown in Fig.4.Values of concentration of V^{4+} , total vanadium ions (N) and their ratio (C), average vanadium site separation (R) and density values are given in Table 2. The densities seems to be decreasing as the dopant (Sb_2O_3) concentration is decreasing. The plots show DC conductivity exhibits an Arrhenius-type temperature dependence given by the relation

$$\sigma=\sigma_0 e^{-W/KT} \qquad \text{...... (1)}$$

Where σ_0 is the pre- experimental factor, W is the activation energy, K is the Boltzmann constant and T is the temperature in Kelvin. From the Fig. 4 it is observed that the conductivity increases with increasing of temperature and also with Sb_2O_3 substitution.

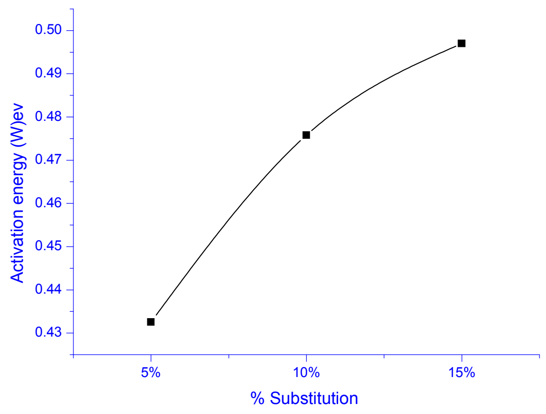


Figure 4 Variation of activation energy with Sb_2O_3 substitution.

Table 2 Composition, density, concentration of V^{4+}, total vanadium ions and their ratio and average vanadium site separation in Sb_2O_3 substituted lead vanadate glass system

Glass composition (mole %)			Density	$[V^{4+}]$	N	C=	R
V_2O_5	PbO	Sb_2O_3	(gm/c.c)	10^{21}/c.c	10^{22}/c.c	(V^{4+}/N)	(Å)
50	45	5	5.006	1.53	1.76	0.0869	3.53
50	40	10	4.552	1.45	1.68	0.0863	3.22
50	35	15	3.963	1.22	1.42	0.0859	3.05

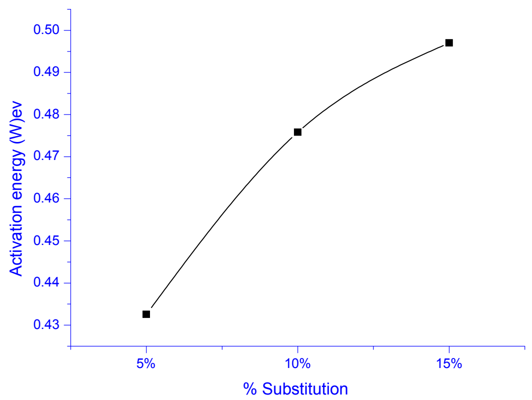


Figure 5 Variation of activation energy with Sb_2O_3 substitution.

Table 3 Activation energies of $xSb_2O_3(50-x)$ $PbO:50V_2O_5(X=5, 10, 15)$.

S.No	% Concentration of Sb_2O_3 Substitution	Activation Energy (W) ev (Obtained from log σ vrs 1000/T plot)
1	5%	0.43
2	10%	0.47
3	15%	0.49

The value of activation energy ranges between0.43eV-0.49eV (see in Table 3).When the energy activation energy value is maximum which means that the corresponding conductivity value is minimum similarly for lower values the conductivity is maximum. In the present case the interesting thing is low activation energies were obtained. The increase in the conductivity is explained based on Anderson and Stuart model. According to this model, as one of the network ions is substituted by another glass modifier ion, the average interionic bond distance becomes larger or smaller according to whether the substituting ion is larger or smaller. From the present results, Sb_2O_3 being slightly larger in size than PbO, the substitution of Sb_2O_3 by PbO will increase the inter ionic bond distance. Thus with the addition of 5, 10 and 15 mol% of Sb_2O_3, the structure becomes loose and hence the conductivity increases (Gedam RS *et al*, 2006). For lead vanadate glasses the hopping process may be either adiabatic or non adiabatic depending on not only on the concentration of PbO but also on the role of the other oxides in the glass matrix Tejeswararao *et al* (Tejeswara Rao P *et al*, 2012; TejeswaraRao P *et al*, 2016) suggested that the glasses containing less than 50mol% PbO are considered as adiabatic conductors. On the other hand many authors reported that for different vanadate glass systems with V_2O_5 content>50mol% [e.g.Bi_2O_3-Fe_2O_3-V_2O_5 (Singh R *et al*, 1989), BaO- V_2O_5- Fe_2O_3 (Bogomolova, L.D *et al*, 1986), BaO-V_2O_5-B_2O_3 (Ghosh A *et al*, 1988), Sb_2O_3- V_2O_5- Fe_2O_3 (Chung C.E *et al*, 1980) the conduction is non adiabatic in nature. Hence from the above considerations in present case may approximate the conduction is adiabatic in nature and small polaron hopping (SPH). The compositional dependence of activation energies for the present glass system is shown in figure 5. As it can be seen from these figures, these plots deviate considerably from the straight-line pattern indicating a non-adiabatic hopping mechanism. The non-linearity of the conductivity curves indicates that the activation energy is temperature dependent in this temperature range.

CONCLUSION

The melt-quenching technique is a very simple method for the preparation of the conducting glasses. Perfect vitrification has been achieved for all the glass samples as can be seen from their X-ray diffractograms of the as prepared samples after annealing at 140^0C. DSC recordings show that eutectic composition of the lead meta vanadate has been maintained for all the glass systems up to 15 mole% of substitution.SEM investigations of the present glass system revealed that there are some micro structural changes are attributing as the substitution (Sb_2O_3) concentration increases. The DC conductivity shows Arrhenius-type temperature dependence and the conductivities of the present samples increased as the dopant concentration increased. The conduction mechanism has to be considered non-adiabatic nature.

Acknowledgements

Authors are thankful to DST-FIST, India, for providing infrastructural facilities equipment through No. SR/FST/PSI-194/2014 Dated: 21st July 2015

References

Al-Shahrani A, Al-Hajry A, El-Desoky MM. (2003).Non-adiabatic small polaron hopping conduction insodium borate tungstate glasses. *Phys Status Solidi a*, 200: 378-387.

Bogomolova, L.D., Glassova., M. P., Kalygina, V.M., Reiman,S.I., Spacibkina, and Filtova, I.V. (1986.J.Non-Cryst.Solids.85,170.

Chung C.E., and Mackenzie, J.D.J. (1980). Non-Cryst. Solids, 42,357.

El-Desoky MM. (2003). Small polaron transport inV_2O_5-NiO-TeO_2 glasses. *J Mater Sci*: *Mater El*, 14: 215-221.

El-Desoky MM, Al-Hajry A, Tokunaga M, *et al.* (2004). Effect of sulfur addition on the redox state of iron iniron phosphate glasses. *Hyperfine Interact*, 156-157: 547-553.

El-Desoky MM, Tashtoush NM, Habib MH. (2005). Characterization and electrical properties of semiconducting Fe_2O_3-Bi_2O_3-$K_2B_4O_7$ glasses. *J Mater Sci*: *Mater El*, 16: 533-539.

Gedam RS, Deshpande VK (2006). An anomalous enhancement in the electrical conductivity of Li_2O:B_2O_3:Al_2O_3 glasses. *Solid State Ionics*, 177:2589-2592.

GhoshA., and Chaudhary B.K., J. (1988). Non-Cryst. Solids, 103,83.

Kim CE, Hwang HC, Yoon MY, *et al*.(2011). Fabrication of a high lithium ion conducting lithium borosilicateglass. *J Non-Cryst Solids*, 357: 2863-2867.

Kiran N, Kesavulu CR, Suresh Kumar A, *et al*. (2011). Spectral studies on Cr^{3+} ions doped in sodium-leadborophosphate glasses. *PhysicaB*, 406:1897-1901.

Mott N.F (1967). Adv.phy, 1967, 16, 49.

Mott N.F (1968). Dissertation, Solids, J.*Non-Cryst. Solids*. 1:1-17.

Pisarski WA, Goryczka T, Wodecka-Dus B, *et al*. (2005).Structure and properties of rare earth-doped leadborate glasses. *Mat SciEng B*, 122: 94-99.

Qiu J, Igarashi H, Makishima A. (2005). Long-lasting phosphorescence in Mn^{2+}:Zn_2GeO_4 crystallitescontaining transparent GeO_2-B_2O_3-ZnO glass-ceramics. *SciTechnolAdv Mater*, 6:431-434.

Saddeek YB, Shaaban ER, Aly KA, *et al*. (2009). Characterization of some lead vanadate glasses.*J Alloys Compd*, 478: 447-452.

semiconducting Fe_2O_3-Bi_2O_3-$K_2B_4O_7$ glasses.*J Mater Sci*: *Mater El*, 16: 533-539.

Singh R, and Sethupathy K (1989).J.Phys. D, 22,702.

Takahashi H, Karasawa T, Sakuma T, *et al*. (2010). Electrical conduction in the vitreous and crystallized Li_2O-V_2O_5-P_2O_5 system. *Solid State Ionics*, 181: 27-32.

TejeswaraRaoP, Ramesh K.V, Sastry D.L, (2012), Electrical and Spectroscopic Studies of the CdO Substituted Lead Vanadate Glass System vs Crystalline Form, New *Journal of Glass and Ceramics*. 2, 34-40.

Tejeswararao P, Ramesh K.V, Sastry D.L, (2016), ESR and DC Electrical Properties of Bi_2O_3-PbO-V_2O_5 Glass System. Physics and Chemistry of Glasses-European *Journal of Glass Science and Technology Part* B. 57: 279-284.

How to cite this article:

Brahmananda Rao K K., Ramesh K V and Tejeswara Rao P.2018, Study of Structural and Dc Electrical Properties of Sb2O3 substituted Lead vanadate semiconducting glass system. *Int J Recent Sci Res.* 9(2), pp. 24291-24294.
DOI: http://dx.doi.org/10.24327/ijrsr.2018.0902.1635

****