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DIELECTRIC DISPERSION AND CONDUCTION BEHAVIOR IN Sn-Se-Pb-Ge GLASS ALLOYS

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Dielectric dispersion in glassy alloys has been studied in frequency range 500Hz-1MHz and in temperature range below glass transition temperature. The results obtained are discussed in terms of "correlated barrier hopping model" proposed by Elliot. Correlation between conductive and dielectric dispersive behavior of glassy alloy has been observed. Variation of ac, dc conductivities and dielectric parameters with composition has also been studied.

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1. Introduction

Amorphous semiconductors have wide possibility of tailoring their physical properties such as electrical, optical, thermal and dielectric behaviors as compare to other crystalline counterpart as per technological requirement. These materials can be synthesized in non stiochemetric composition easily because of flexibility in structure. In amorphous semiconductors chalcogenide glasses mark their own importance in electrical or memory switching and in non-linear optical and electrical devices. Chalcogenide glasses are the alloy or compounds of group VI elements S,Se and Te with III,IV, V group elements. These materials offer their applications such as telecommunication devices, waveguides, multiplxier, demultiplxers due to their high index of refraction and non linearity of electrical and optical properties of glass media [1-3]. They are also used in other photonic applications due tunable transparency in mid to near infrared region, high index of refraction and low optical losses [4-7].

Se-Ge based glassy system has been widely investigated for last few decades due to their good glass forming ability, high T_g and wide glass forming region. But these systems have certain disadvantages such as large value of band gap and optical losses. Researchers in this field are still in an effort to tailor these compositions to have good glass forming ability (GFA), low optical losses along with tunable dielectric and optical properties for making suitability for switching devices or other photonic application. Ge, Pb elements have been added to tailor these physical properties with in glass forming region. The element Pb is added because of its greater atomic radii than Ge which produces configurational disorder in glassy network. It acts as good tailoring agent for glass transition temperature and band gap of Pb-Ge-Se system [8-10]. The added substituent affects the basic bonding network and therefore the band structure of material

The density of defect states has the pronounced effect on mobility gap in amorphous semiconductors to control the optical and electrical properties of the material. The study of defect centers helps us understand dielectric dispersion mechanism in the chalcogenide glasses. These amorphous semiconductors cover the range of electrical conductivity 10^{-2}-10^{-16} Ω^{-1} cm^{-1}[11]. Defect states include the D^+ and D^- states. Elliot proposed the Correlated Barrier Hopping Model (CBH) model based on density of defect statesD^+ and D^- in chalcogenide glasses [12,13]. For the study of dielectric dispersion, correlated barrier hopping model (CBH) of bipolarons (two-electron

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hopping charged defects D^+ and D^-) has been proposed. Hole hops between D^o and D^- states and electron between D^+ and D^o state. The temperature dependence of ac conductivity is predicted by the correlated barrier hopping model (CBH), which increases with rise in temperature. According to Shimkawa [14] CBH model of single polaron become dominant at higher temperature. The dc conduction in amorphous semiconductors takes place via hopping or tunneling of charge carriers in the infinite percolative clusters.

2. Experimental Details

The material$Sn_8Se_{74}Pb_{18-x}Ge_x$ ($7 \leq x \leq 11$) has been prepared by the melt quenching technique and amorphous nature of the material is ascertained by powder X-ray diffraction technique using an X-ray diffractometer Panalytical X'pert Pro (PW 3050/60, $CuK_{\alpha 1}$ $\lambda = 1.54$ Å) at room temperature as shown in fig.1.The glassy nature of alloy is also ascertained using the differential scanning calorimetry (DSC).The material has the high value of glass transition temperature (T_g) and glass transformation region. T_g varies from 408K to 432K as Ge content varies from 7 to 11 atomic percentage [15].

The pellets are coated with silver paste on both sides to ensure good electrical contact with the electrodes of the sample holder. The pallets are analyzed for dielectric behavior with impendence analyzer (Wayne Kerr 6500B). Dielectric behavior has been studied in the frequency range 500Hz-1MHz and in temperature range 310K-365K well below the glass transformation region to avoid structural relaxation in glassy matrix. For dc conductivity at different temperature dc voltage in 0-100V range is applied and the resulting current is measured using digital picometer (Keithley, model 2611).

3. Results and Discussions

3.1. Dielectric Dispersion at Room Temperature:-

3.1.1 Dielectric Constant

In dielectric media there is a lag between change in polarization and change in electric field. The dielectric constant is a function of frequency of electric field. The values of dielectric constant are calculated by using the relation

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

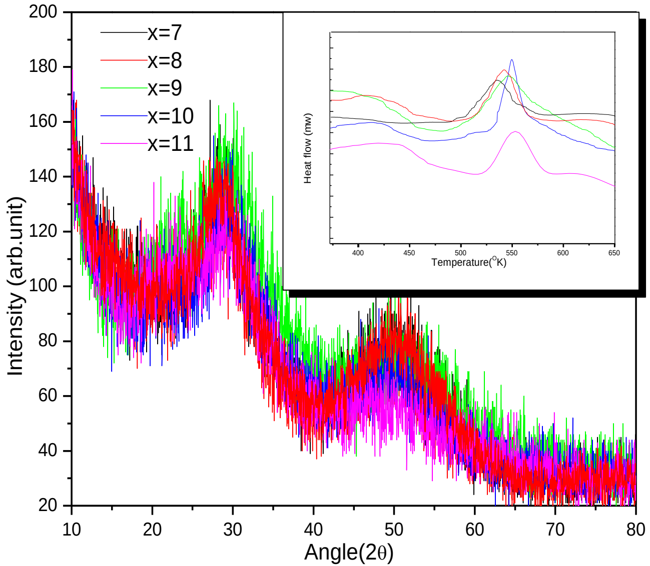

Fig.1 X-Ray Diffractograms and DSC thermograms at heating rate of 10K min^{-1} (inset) for $Sn_8Se_{74}Pb_{18-x}Ge_x$($7 \leq x \leq 11$) glassy alloys.

Here C is the capacitance of the material, d is the thickness of pellet, ε_o is the permittivity of the free space and A is the area of the pellet. A small decrease in dielectric constant at room temperature has been observed up to frequency 100 KHz for samples at x=7,8,9 and above this frequency approximately remains constant. However for samples at x=10,11 there is comparatively very small variation with frequency has been observed up to 10 KHz there after it practically remains constant as shown in inset (a) of figure 2. With the increase in frequency, orientational polarization decreases. The dipoles are unable to orient themselves at higher frequency at room temperature. So a small decrease in dielectric constant with frequency at room temperature has been observed [16]. The difference of dialectical dispersion behavior with composition variation might be due to variation in concentration of density of defect states. As the Ge content increases in the glassy matrix cross linking increases due to fourfold coordination of Ge, which reduces the density of defect states (D^+, D^-) appreciably. So the polarization effect in the glassy matrix reduces with rise in Ge content, hence the dielectric dispersion.

3.1.2 Dielectric Loss

The imaginary part of dielectric susceptibility is dielectric loss, which is determined by using the relation [16],

$$\varepsilon'' = \varepsilon'\tan\delta \tag{2}$$

Here tanδ is equivalent to the dissipation factor (D) obtained by the impedance analyzer, which quantifies the inherent dissipation of electric field energy in dielectric material. It decreases with frequency for x=7,8,9 and for x=10,11 it approximately remains constant. The inset (b) in figure 2 shows the dielectric loss (ε'') variation with frequency. The dielectric loss decreases with frequency at room temperature

3.1.3 AC Conductivity Behavior

Material's pallets are studied for conducting behavior in the frequency range 500Hz-1MHz below glass transformation region. The total conductivity of dielectric material can be written as [17]

$$\sigma(\omega) = \sigma_o + A\omega^s \tag{3}$$

The term σ_o is low frequency (or dc) conductivity. The value of dc conductivity is negligible as compared to the total conductivity. So σ_o can be neglected and total conductivity isapproximately equal to ac conductivity. Here $\omega=2\pi f$ is the angular frequency, where A is prefactor and s is the frequency exponent. Both these factors have the dependence on the temperature .The value of s approaches to unity at room or low temperature. Dielectric dispersion has been observed for x=7 above 10KHz, for x=8,9 above 50K Hz and for x=10,11 above 100KHz. Graphs depicts that the point of inflection at which the ac conductivity rises suddenly shift to high value of frequency with rise in Ge content. This may be due to the decrease in density of defect states. With rise in the Ge concentration glassy network strengthen which is not easy to polarize. So this shift in ac conductivity behavior has been observed as shown in fig. 2. The variation of ac conductivity at room temperature shows that hopping of the charge carriers between the pairs of localized states at Fermi level takes place. The $\sigma_{ac}(\omega)$ can be correlated with density of localized states $N(E_f)$ at Fermi level as [18]

$$\sigma_{ac}(\omega) = \frac{\pi}{3} e^2 k_B T [N(E_f)]^2 \alpha^{-5} \omega [\ln(\frac{v_{ph}}{\omega})]^4 \tag{4}$$

Here e the electronic charge, v_{ph} is the phonon frequency, α is the exponential decay parameter of localized state wave function and k_B is the Boltzman constant. In compositional variation, the addition of Ge in the glassy matrix decreases the defect states and the ac conductivity decreases with increasing Ge concentration.

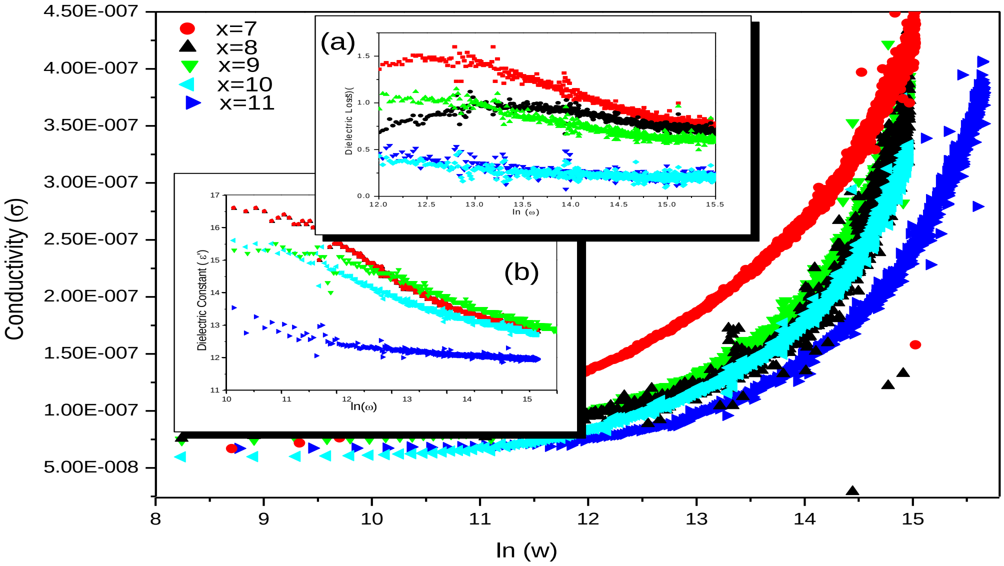

Fig.2 Variation of ac conductivity, dielectric loss (inset (a)) and dielectric constant (inset (b)) with frequency at room temperature for $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(*$7 \leq x \leq 11$*) glassy alloys*

3.2 Temperature and Frequency Dependence of ac Conductivity

The mechanism of ac conduction in chalcogenide glasses follows the relation

$$\sigma_{ac}(\omega) = A\omega^s \tag{5}$$

The frequency exponent *s* in this equation can be expressed as [13]:

$$s = 1 - \frac{6K_B T}{[W_b + k_B T ln(\omega\tau_o)]} = \frac{d(\ln(\sigma_{ac}))}{d(\ln(\omega))} \tag{6}$$

Where K_B is the Boltzmann constant, ω is angular frequency,τ is the relaxation time for the electron to hop over the barrier, *T is* the absolute temperature, W_b is the maximum barrier energy required to move electron from the *localized site* to extended site. The frequency dependence of the ac conductivity at different temperatures for glassy material is shown in figure 3. The frequency exponent(s) varies inversely with temperature and approaches to unity at lower or room temperature. The Values of s has been obtained of from the plots of$ln(\sigma_{ac})$ versis $ln(\omega)$. Variation of s with temperature for all alloys is shown in figure 4. The behavior of *s* (*T*) is according to the correlated barrier hopping (CBH) model proposed by Elliot, where he elaborated the non intimate valence alternation pairs (NVAP's). In NVAP's hopping takes place between close pairs of defect centers which have the random distribution of charged centers. Similar observations have been repeated in literature by various authors [5,18-21]. The AC conductivity behavior is studied in the temperature range below the T_g, We see that at room temperature in low frequency range conductivity is almost constant and increases exponentially in high frequency range showing universal behavior. AC conductivity values increases as the temperature increases. The values of ac conductivity at different temperatures and frequencies for glassy alloys are tabulated in table 1.

Table 1 Values of ac conductivity of $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(*$7 \leq x \leq 11$*) glassy alloys at different temperature and frequencies.*

x	frequency	ac conductivity(Ω^{-1} cm^{-1}) at		
		315K	355K	365K
x=7	50KHz	$1.25X10^{-10}$	$2.04X10^{-09}$	$2.52X10^{-09}$
	500KHz	$6.16X10^{-10}$	$3.03X10^{-09}$	$3.76X10^{-09}$
	1MHz	$1.26X10^{-07}$	$1.40X10^{-07}$	$1.51X10^{-07}$
x=8	50KHz	$1.37X10^{-09}$	$4.65X10^{-09}$	$6.85X10^{-09}$
	500Kz	$2.06X10^{-09}$	$8.38X10^{-09}$	$1.03X10^{-08}$
	1MHz	$1.96X10^{-07}$	$2.40X10^{-07}$	$2.55X10^{-07}$
x=9	50KHz	$5.77X10^{-10}$	$2.05X10^{-09}$	$2.79X10^{-09}$
	500KHz	$6.88X10^{-10}$	$3.11X10^{-09}$	$4.62X10^{-09}$
	1MHz	$1.29X10^{-07}$	$1.44X10^{-07}$	$1.54X10^{-07}$
x=10	50KHz	$3.74X10^{-09}$	$2.33X10^{-08}$	$2.76X10^{-08}$
	500KHz	$8.70X10^{-09}$	$6.24X10^{-08}$	$7.83X10^{-08}$
	1MHz	$3.81X10^{-06}$	$8.15X10^{-06}$	$9.37X10^{-06}$
x=11	50KHz	$4.30X10^{-11}$	$1.69X10^{-10}$	$2.08X10^{-10}$
	500KHz	$1.95X10^{-10}$	$3.44X10^{-10}$	$4.24X10^{-10}$
	1MHz	$4.50X10^{-08}$	$8.40X10^{-08}$	$1.13X10^{-07}$

In the plots of ln(σ_{ac}) versus 1000/T shown in Figure 5 are approximately straight lines at different frequencies. These straight line fits confirm the ac conduction mechanism dependence with temperature in the intermediate temperature range [20] as;

$$\sigma_{ac}(\omega) = \sigma_o e^{\left(\frac{-\Delta E}{K_B T}\right)} \tag{7}$$

Where σ_o is constant. ΔE_{ac} (ω) is activation energy of ac conduction is calculated at different frequencies using this equation. Variation of $\Delta E_{ac}(\omega)$ with frequency for all glassy alloys is plotted in figure 6 and values are tabulated in table 2. $\Delta E_{ac}(\omega)$ decreases with increasing frequency, because increase in applied field frequency enhances the electronic jump between the localized states [5].

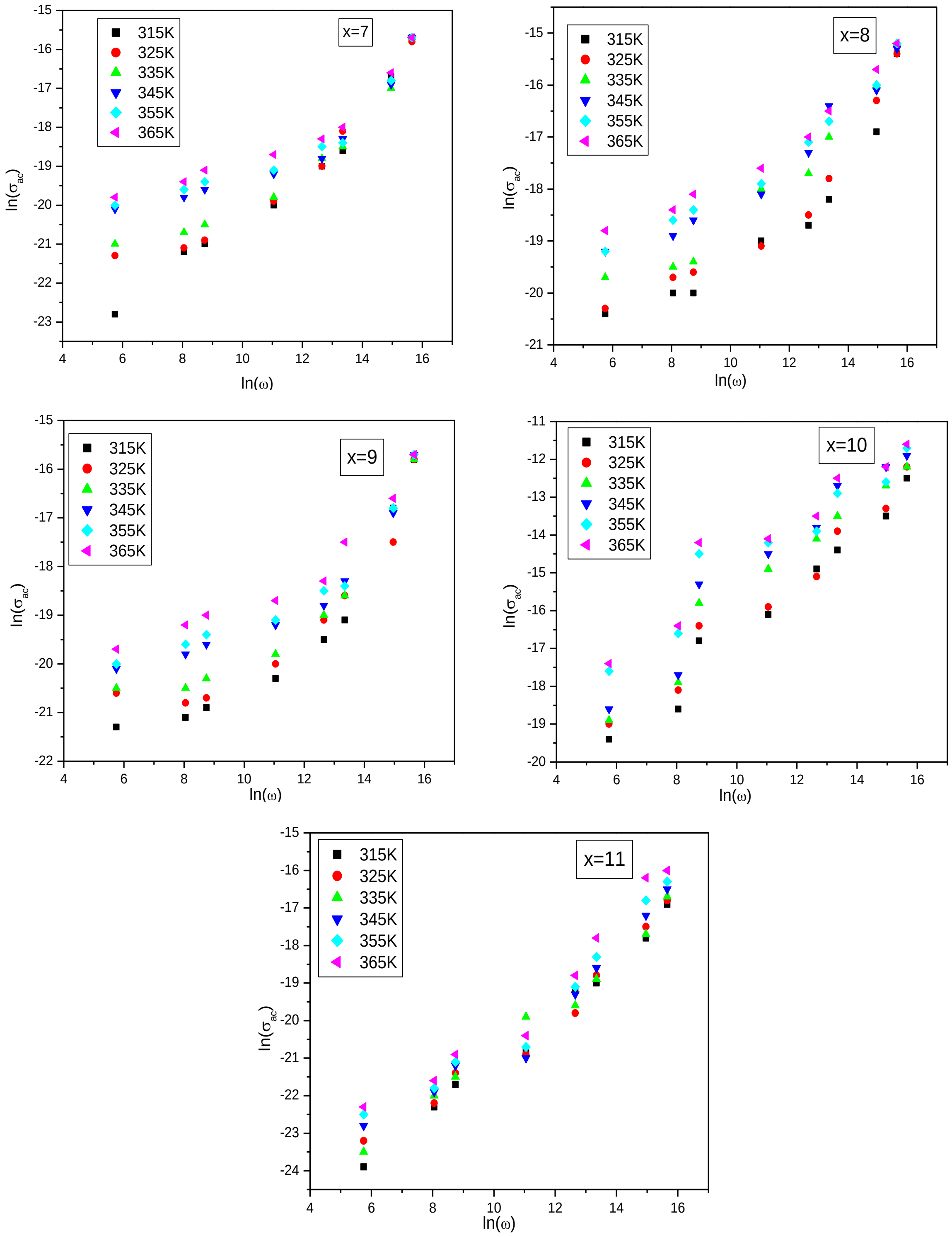

Fig. 3 Variation of $ln(\sigma_{ac})$ *with* $ln(\omega)$ *at different temperature forfor* $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(7≤x≤11) glassy alloys*

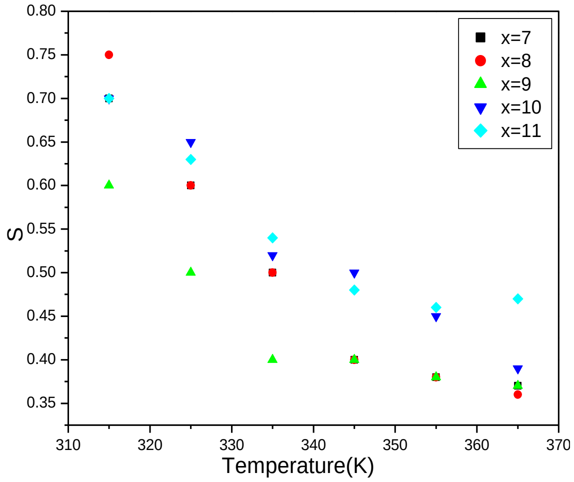

Fig. 4 Variation of frequency exponent (s) with Temperature for $Sn_8Se_{74}Pb_{18-x}Ge_x$ ($7 \le x \le 11$) glassy alloys

Table2 Values of ac activation energy for $Sn_8Se_{74}Pb_{18-x}Ge_x$ ($7 \le x \le 11$) glassy alloys at different frequencies

Frequency	ac activation energy(eV) at				
	X=7	X=8	X=9	X=10	X=11
500 Hz	0.2809	0.3542	0.3800	0.5429	0.4248
1K Hz	0.3481	0.3955	0.3671	0.4826	0.2654
10K Hz	0.3438	0.1879	0.2102	0.4214	0.3059
50K Hz	0.1809	0.0595	0.1309	0.2464	0.1688
100KHz	0.0801	0.0706	0.1370	0.1293	0.2576
500KHz	0.0049	0.0233	0.0050	0.0517	0.1379
1MHz	0.0034	0.0371	0.0362	0.0603	0.0595

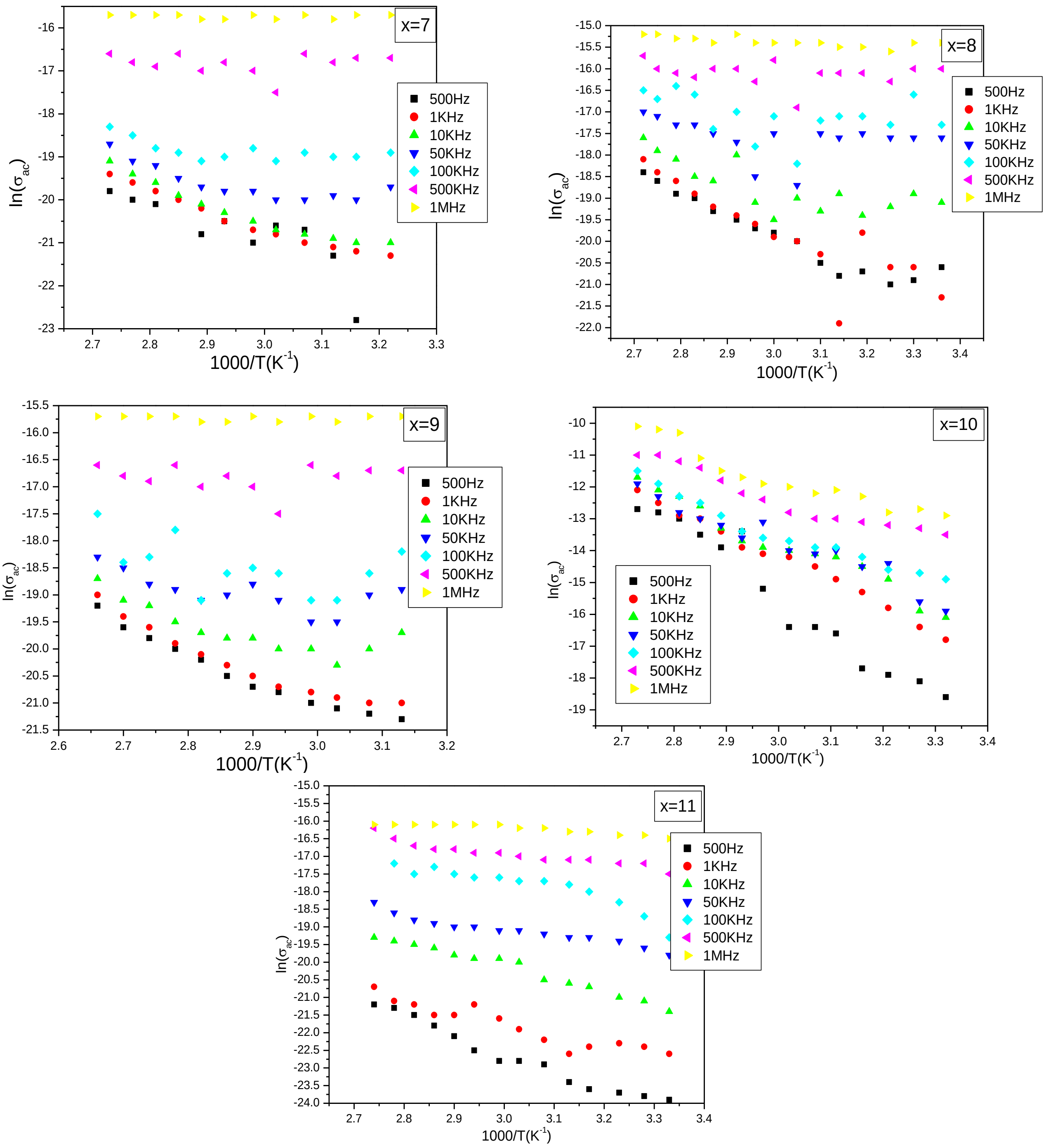

Fig. 5 Variation of $\ln(\sigma_{ac})$ with 1000/T at different frequencies for $Sn_8Se_{74}Pb_{18-x}Ge_x$ (7≤x≤11) glassy alloys

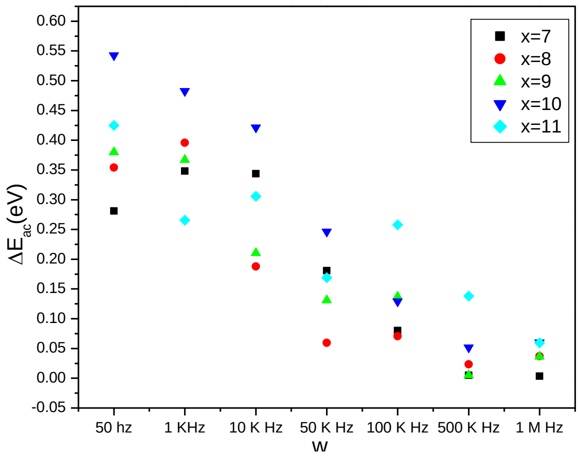

Fig. 6 The ac activation energy at different frequencies for $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(7≤x≤11) glassy alloys*

DC conductivity has been studied from the I-V (current- voltage) characteristics by digital picometer (Keithley, model 2611) at different temperatures. σ_{dc} has been found by

$$\sigma_{dc} = \frac{Id}{VA} \tag{8}$$

Here I is the current, d is the thickness of the pallet, V is the voltage applied and A is the area of pallet. The values of the dc conductivities are tabulated in Table 3

Table 3 Values of dc conductivity for $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(7≤x≤11) glassy alloys at different temperatures*

Temperature (Kelvin)	DC conductivities ($\Omega^{-1}cm^{-1}$) for				
	X=7	x=8	X=9	X=10	X=11
313	7.0027×10^{-10}	3.0814×10^{-10}	1.04589×10^{-10}	5.2069×10^{-10}	1.1554×10^{-11}
323	1.7487×10^{-9}	1.3329×10^{-9}	1.3650×10^{-10}	2.5169×10^{-11}	7.9883×10^{-11}
333	4.8227×10^{-9}	1.4532×10^{-9}	2.3488×10^{-10}	1.8078×10^{-10}	1.6389×10^{-10}
343	7.1694×10^{-9}	1.9084×10^{-9}	8.7324×10^{-10}	2.5235×10^{-10}	1.6463×10^{-10}
353	1.2220×10^{-8}	3.8390×10^{-9}	2.6019×10^{-9}	4.5309×10^{-10}	4.2524×10^{-10}
363	1.5821×10^{-8}	6.79166×10^{-9}	7.7716×10^{-9}	7.7205×10^{-10}	9.06378×10^{-10}

Temperature dependence of dc conductivity of glassy alloys has been shown by plot of $ln(\sigma_{dc})$ versus 1000/T for $Sn_8Se_{74}Pb_{18-x}Ge_x$ (7≤x≤11) glassy alloys which are approximately straight lines. This indicates the thermally activated process in the localized states and confirms the relation [20];

$$\sigma_{dc} = (\sigma_o)_{dc} e^{\left(\frac{-\Delta E_{dc}}{K_B T}\right)} \tag{9}$$

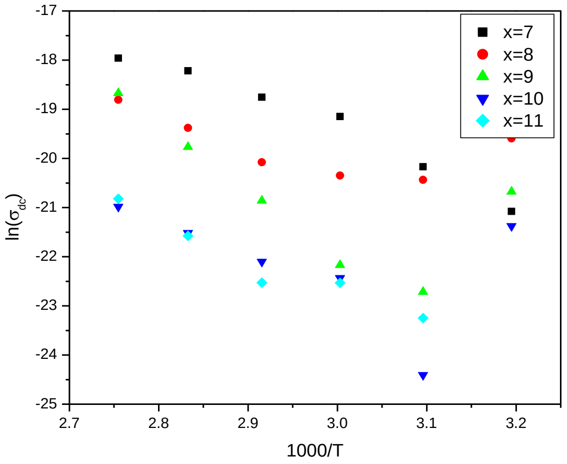

Fig. 7 Variation of $ln(\sigma_{dc})$ *with 1000/T at different temperatures for* $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(7≤x≤11) glassy alloys*

The dc activation energy has been found from the slopes of straight lines in the plots $of\, ln(\sigma_{dc})$ with 1000/T at different temperatures. The ΔE_{dc} for $Sn_8Se_{74}Pb_{18-x}Ge_x$ (7≤x≤11) glassy alloys are found to be 0.4275eV, 0.5438eV, 0.5440eV, 0.5131eV and 0.6284eV respectively. Activation energy increases with increasing Ge content for the compositions of the system under investigation. Because of the small size of Ge than Pb atom, the Ge atoms bind their valence electrons more tightly than the Pb atoms do [22]. As the number of Ge atoms increases, the difference in energy between the bonding and antibonding states at the band edge increases. Increasing cross linking in glassy network due to increase in Ge content or decrease in Pb content consequence decrease in density of states and hence increase in activation energy of conduction

2.3.3 Dielectric Constant and Dielectric Loss Behavior with Temperature

Temperature dependence of dielectric loss and constant is appreciable in certain temperature ranges. However at low temperature dielectric constant is almost invariable. The dielectric loss and constant is studied with varying temperature before phase transformation in frequency range upto 1MHz.Dielectric loss (ε″) behavior with angular frequency (ω) follow the relation as [23-24]

$$\varepsilon'' = B\omega^m, \quad m<1 \tag{10}$$

Here B is constant. Loss behavior of material is shown in plot of ε″ and ln(ω) in Figure 8. Loss behavior is also confirmed from the straight line graph between ln(ε″) and ln(ω) shown in Figure 9. Exponent m in the relation has been calculated from the slope of straight lines and it is negative for all compositions. Elliot's idea of hopping conduction dielectric relaxation in amorphous semiconductors was confirmed and modified by Guintini[23-24] in his model. Elliot had given idea of hopping of charge carrier over the potential barriers between the charged defect states [12,25]. This potential barrier is due to Coulombic interaction between neighboring dipole forming sites. Defect states are also responsible for the conduction mechanism of the material. These defect states are D^+ and D^-. The relaxation time of charge carriers is an intensive variable of activation energy. This model suggest that ε″ at a particular frequency and temperature range where dielectric dispersion occurs depends upon the relation as follows [23],

$$\varepsilon'' = (\varepsilon_o - \varepsilon_\infty)\, 2\pi^2 N \left(\frac{ne^2}{\varepsilon_o}\right)^3 \kappa_B T \tau_o^m W_m^{-4}\, \omega^m \tag{11}$$

Where n is the number of electrons that hop, N is the concentration of localized sites, ε_o is static dielectric constant, ε_∞ dielectric constant at infinitely high frequencies. W_m is the maximum barrier height calculated from the slopes of the straight lines obtained from plots between m and temperature shown in Figure 10. The relaxation time is also given by

$$\tau = \tau_o exp(\frac{W}{K_B T}) \tag{13}$$

The value of m is calculated by using the relation;

$$m = \frac{-4\kappa_B T}{W_m} \tag{12}$$

With the increase in frequency dielectric loss decreases and increases with rise in the temperature which is clear from equation (11). The values of W_m are 0.0481eV, 0.030 eV, 0.0352 eV, 0.0058 eV and 0.0448 eV for x= 7, 8, 9, 10, 11 respectively in $Sn_8Se_{74}Pb_{18-x}Ge_x$ ($7 \leq x \leq 11$) glassy alloy. The values of dielectric loss at different frequencies for 325K, 345K and 360K temperatures are tabulated in Table 4. The dielectric loss increases as the temperature increases and variation with frequency is large at lower temperature and at higher temperature its variation with frequency is negligibly small.

Table 4 Values of dielectric loss at 325K, 345K and 360K temperatures observed at different frequencies for $Sn_8Se_{74}Pb_{18-x}Ge_x$ ($7 \leq x \leq 11$) glassy alloys

Temperature	frequency	Dielectric loss for				
		X=7	X=8	X=9	X=10	X=11
325K	500Hz	4.66	2.75	2.16	3.84	0.80
	1K Hz	2.66	1.70	1.36	2.42	0.97
	10K Hz	0.75	0.87	0.90	2.2	0.55
345K	500Hz	12.25	5.57	6.22	5.89	1.58
	1K Hz	7.13	3.38	3.44	2.42	0.77
	10K Hz	1.07	0.88	0.85	2.20	0.51
360K	500 Hz	29.69	13.82	16.95	14.89	19.11
	1 K Hz	19.45	9.02	10.08	9.02	14.57
	10 K Hz	3.06	1.61	1.52	2.42	3.91

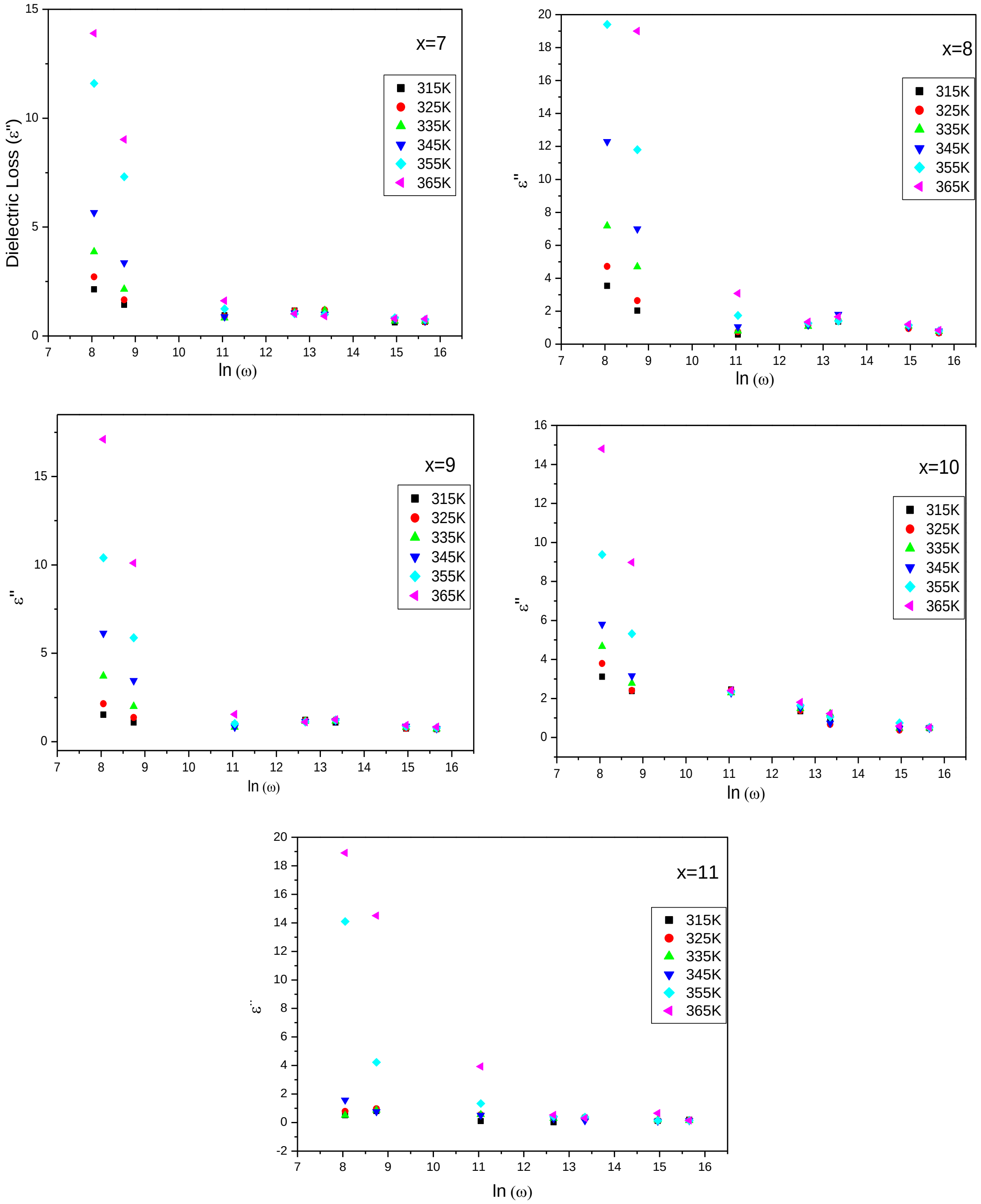

Fig. 8 Variation of ε'' *with* $ln(\omega)$ *at different temperatures for* $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(*$7\leq x\leq 11$*) glassy alloys*

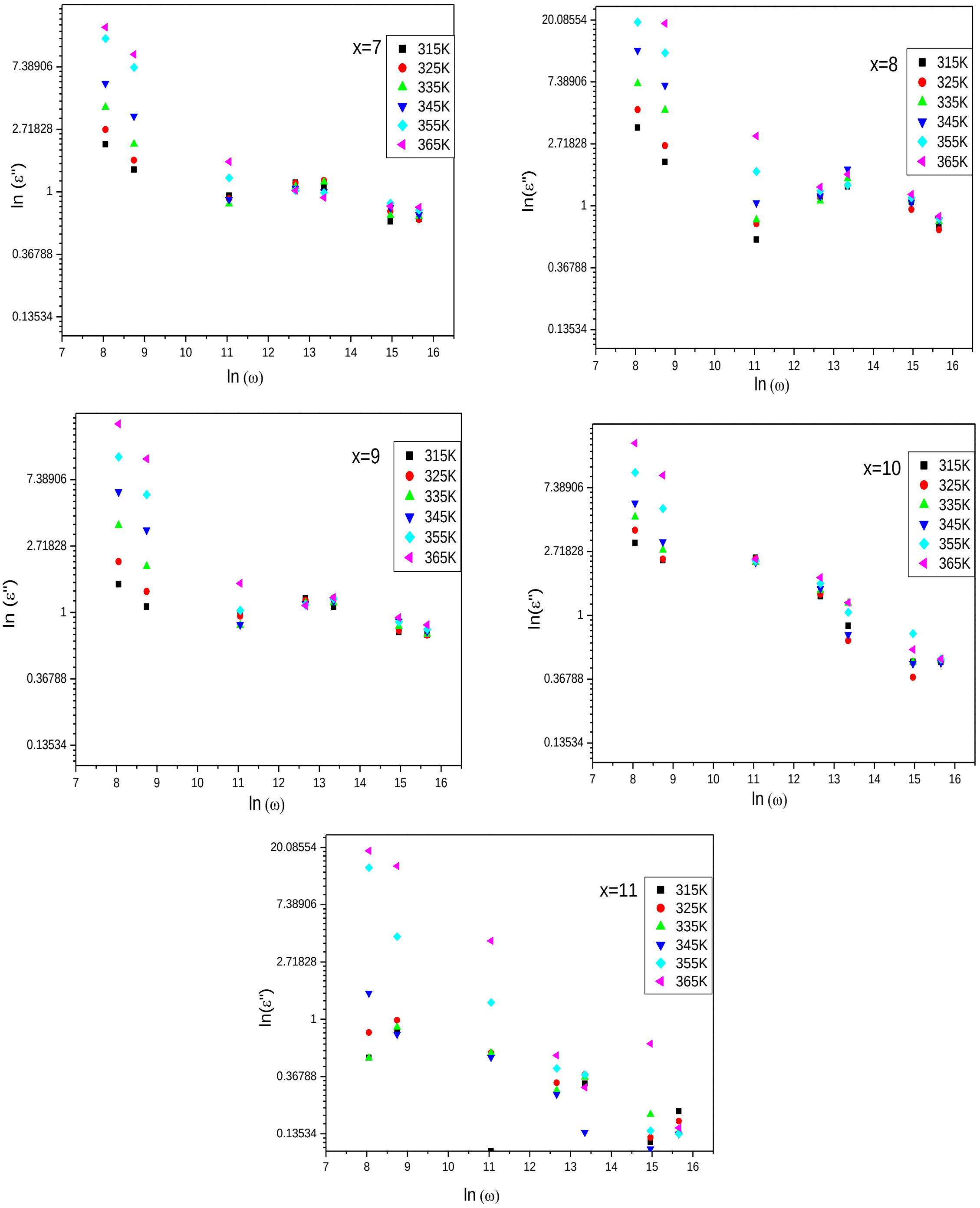

Fig. 9 Variation of $\ln(\varepsilon'')$ *with* $\ln(\omega)$ *at different temperatures for* $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(7≤x≤11) glassy alloys*

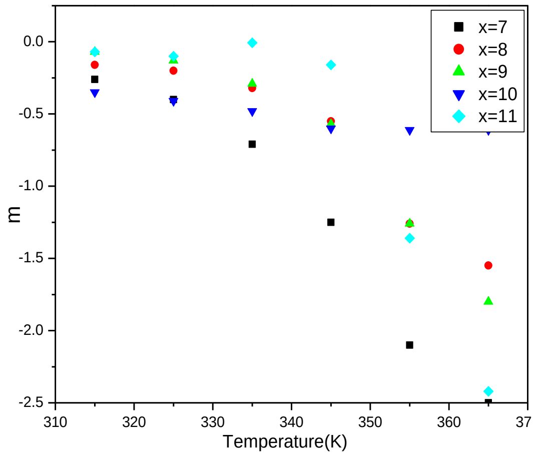

Fig. 10 Variation of parameter 'm' with temperature for $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(*$7 \leq x \leq 11$*) glassy alloys*

Figure 11 shows that dielectric constant (ε') increases with the temperature and is different at different frequencies. Variation of dielectric constant with increase in temperature is larger at lower frequencies. Figure 11 shows that the dielectric constant at higher frequency (at 10 KHz or above) becomes approximately invariable with temperature.

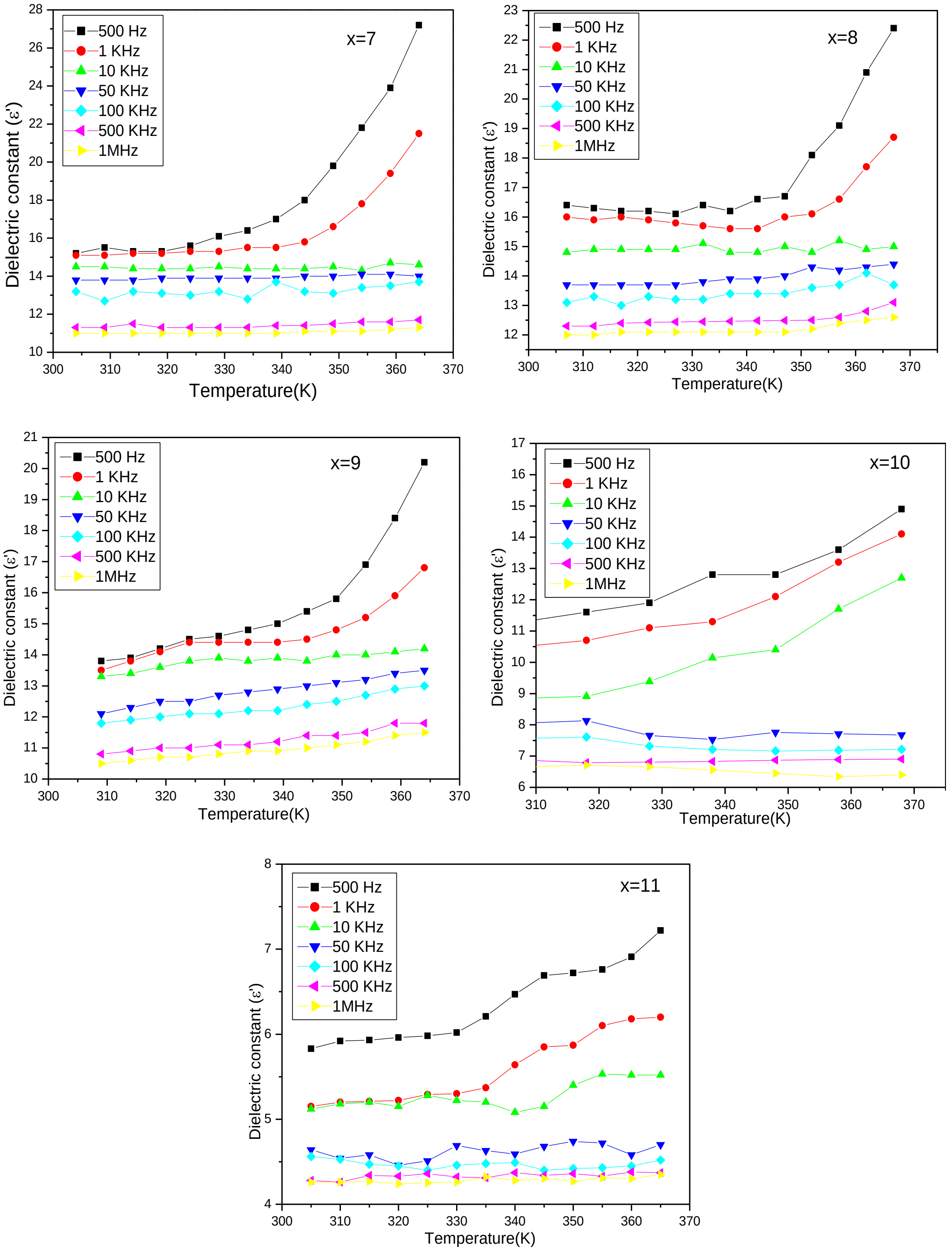

Fig. 11 Variations of dielectric constant (ε') with the temperature at different frequencies in for $Sn_8Se_{74}Pb_{18-x}Ge_x$ *(7≤x≤11) glassy alloys*

8. Discussions

The decreasing dielectric constant with increasing frequency at different temperatures is due to contribution from various components of the polarization such as ionic, electronic, orientational and space charge polarization. These polarizations are responsible for the variation of dielectric constant with ac field frequency. Moreover ionic polarization does not have the pronounced effect in the total polarization, as material possess the good percentage covalent character [20]. Different bonds in the material possess the covalent character whose percentage can be given as;

Covalent character=$100\%\exp(0.25(\chi_A-\chi_B)^2)$

Here χ_A, χ_B are the electronegativities of atoms A and B respectively. The percentages of covalent character for different bonds are as Pb-Se 98.79%, Ge-Se 92.97% and Sn-Se 91.66%. [26].

Dielectric constant increases as the temperature rises over the whole frequency range because of thermal motion of molecules. Dielectric constant increase is slow at lower temperature and sharper at high temperature as shown in figure 8. The dipoles can't orient themselves at the low temperature and remain frozen. As the temperature increases the orientation of the dipoles is facilitated and thus orientation polarization increases. At higher temperature dipoles become rotationally free and then effect of molecular interaction energy diminishes as compare to thermal energy [27], so dielectric constant increases as temperature increases. When the applied field frequency increases, the magnitude of orientational polarization decreases as it takes more time than electronic polarization and hence dielectric constant decreases. As the field frequency increases, the dipoles no longer remain able to rotate or oscillate sufficiently to follow the field. Thus at the high frequency of applied field, dipoles completely become unable to follow the field. Hence dielectric constant decreases with increasing frequency and approaches to constant value at higher frequency. Density of defect states decreases with increasing concentration of Ge in material which reduces polarization and thus dielectric constant decreases. There is the frequency dependence of the dielectric loss also which follows the $\varepsilon'' \propto \omega^m$ relation.

The origin of the dielectric loss according to Stevels [28], may be conduction loss, dipole loss and vibration loss. The conduction loss involves the migration of ions over the large distance, when the ions jumps over the highest potential .As the ions move they impart some of their energy to lattice as heat and this heat lost per cycle of field is proportional to σ/ω. At low temperature these losses are small, as the temperature increases these losses also increase. So the dielectric loss increases with rise in the temperature. ε''decreases with increasing frequency. The migrations of ions at low frequency are the source of the dielectric loss. At low or moderate range of frequency there is high value of dielectric loss due to ions jumps, conduction loss of the ions migration and ion polarization loss. At high field frequency ions vibrations is the only source of dielectric loss, so the ε'' falls at the higher frequency.

9. Conclusion

Dielectric dispersion and conductivity behavior of quaternary glass has been studied. The ac conductivity behaviors follow the power law ω^s. The frequency exponent's' approaches unity at room temperature or decreases as temperature rises. A decrease has been observed in ac and dc conduction with increase in Ge content in the material. This is due to the decrease in the density of localized states and band tailing. Density of defect states and band tailing are the main factors which affect ac and dc conduction behavior with temperature and frequency. The obtained results agree with the theory of hopping of charge carriers proposed by Elliot. Dielectric dispersion and conduction mechanism have been interpreted in accordance to CBH model.

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