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Physico-Chemical Properties of $Ge_{40}Te_{60-x}Sb_x$ Glassy Alloy

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Abtract:-

We have systematically studies the physic-chemical; properties of glassy $Ge_{40}Te_{60-x}Sb_x$ system. Various chemical properties have been determined using different theories. Addition of Sb to $Ge_{40}Te_{60}$system was found to affect optical electronegativity, fractional ionic character and the degree of covalent character.

Keywords:- Optical electronegativity, Ionic and Covalent character.

Introduction:-

The metal semiconductors occupy a unique place in material science not only due to their chemical, optical and thermal properties, but also due to their important role towards the advancement of technology [1-3]. Chemical properties of chalcogenide glasses have attracted significant attention because of their remarkable applications in radiating sensing of nuclear waste, mid-infrared Laser and many other technological field [4-5]

Chalcogenide materials, especially those containing Ge and Te, are of importance in modern technology due to the following reasons: -
(1) Large change in optical constants between crystalline and amorphous state
(2) Rapid phase transition between amorphous and crystalline (two stable states) states.[6]
In the view of the above, here we concerned with the theoretical prediction of the compositional effect on the physic-chemical properties and how to correlate the different chemical parameter of $Ge_{40}Te_{60-x}Sb_x$ (x = 0, 2, 4, 6 and 10) glassy alloy.

Theory and Discussion:-

[A] Optical Electronegativity:-

The optical electronegativity is an important parameter that relates to many physic-chemical parameters of the materials as suggested by Duffy [7]. The optical electronegativity $\Delta\chi$ is the tendency of an atom or radical to attract electrons from the ionic bond. Duffy suggested a model that can be applied for all the compositions used in opto-electronic structure. The model correlates the relation between the energy band gap E_g and electronegativity $\Delta\chi$ by the equation-

$$\Delta\chi = 0.2688\ E_g \qquad (1)$$

The obtained value of E_g have been reported in previous paper [8], and the value of $\Delta\chi$ and E_g

are listed in table-1. The variation of $\Delta\chi$ with E_g are illustrated in Fig.-1.From the Fig.-1, it is shows that optical electronegativity decreases with decrease in energy band gap E_g .

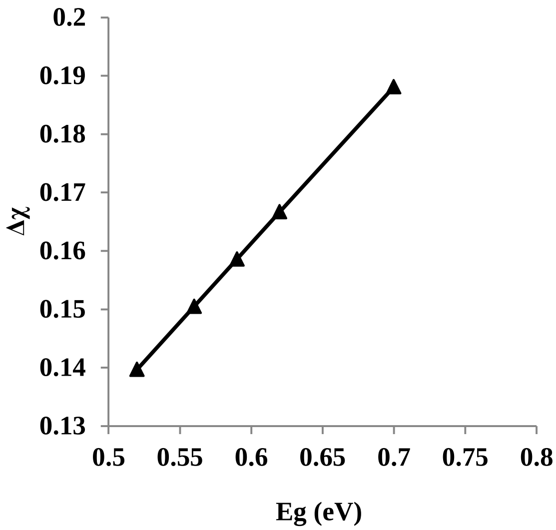

Fig.-1:- Variation of $\Delta\chi$ with E_g

[B] Fractional Ionic Character:-

Pauling [9] developed a thermo chemical method to formulate a reliable relationship between fractional character or iconicity of a bond and the difference in electronegativities of atoms forming the chemical bond. Following the theory due to Pauling, a relationship between fractional ionic character fi and electronegatovity difference $\Delta\chi$ is considered as given below-

$$f_i = 1 - [\exp\{-(\Delta\chi)^2/4\}] \times 100\% \qquad (2)$$

The calculated value of f_i is listed in table-1 and the variation of f_i with $\Delta\chi$ is illustrated in Fig.-2 from the Fig.-2 it is clear that the variation of f_i decreases with the decrease in $\Delta\chi$.

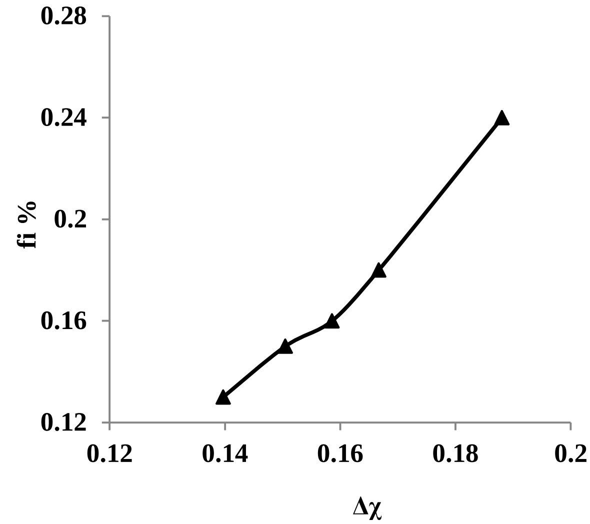

Fig.-2:- Variation of fi with $\Delta\chi$

[C] The degree of covalence character:-

Chalcogenide glasses are formed from materials like sulpher, selenium, arsenic, germanium, and tellurium which have predominantly covalent bonds; the degree of covalence in the bond of glassy system under investigation can be calculated by using the Pauling relationship [10] as given below-

$$C_c = 100\exp[-\Delta\chi/4]^2\% \qquad (3)$$

The calculated value of C_c is listed in table-1 and the variation of C_c with $\Delta\chi$ is illustrated in Fig.-3.From the Fig.-3 it is shoes that covalent character increases with the decrease in electronegativity.

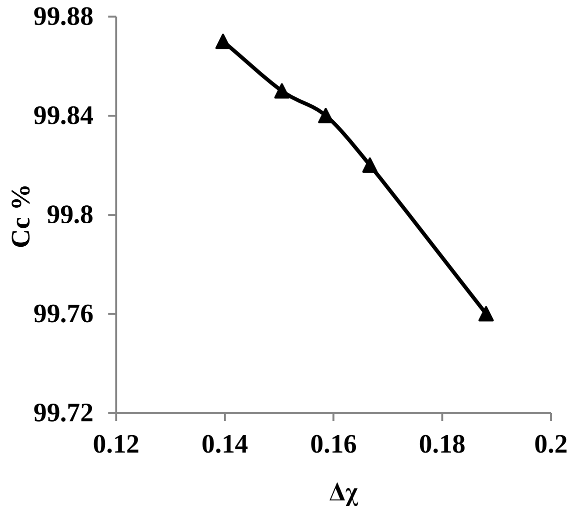

Fig.-3: Variation of Cc with Δχ

Table-1: The value of E_g , Δχ , f_i and C_c for the $Ge_{40}Te_{60-X}Sb_x$glassy system

X at %	Eg(eV)	Δχ	fi%	Cc%
$Ge_{40}Te_{60}$	0.70	0.1881	0.24	99.76
$Ge_{40}Te_{58}Sb_2$	0.62	0.1667	0.18	99.82
$Ge_{40}Te_{56}Sb_4$	0.59	0.1586	0.16	99.84
$Ge_{40}Te_{54}$ Sb_6	0.56	0.1505	0.15	99.85
$Ge_{40}Te_{50}Sb_{10}$	0.52	0.1397	0.13	99.87

Conclusion-

It is concluded here that the variation in Sb content in Ge-Sb-Te glassy alloys leads to change in the physic-chemical properties. As it is clear from various figures and table given that almost all the parameters, except the parameter E_g, **Δχ** , and f_i decreases with the increase in content of Sb in $Ge_{40}Te_{60-x}Sb_x$ system. It has been found that Cc is proportional to composition x and increases with the increase in content of Sb from 0 to 10 at %, resulting in decrease of optical band gap and **Δχ.**

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