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Non-linear Optical Analysis of $(Ge_{0.17}Se_{0.83})_{100-X}In_X$ Chalcogenide glassy systems

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Abstract:- *Ternary* $(Ge_{0.17}Se_{0.83})_{100-X}In_X$ *Chalcogenide glassy alloys has been prepared by melt quenching technique. Various non-linear optical parameters such as third-order non-linear suspectibility (* $\chi^{(3)}$*) and non-linear refractive index(*n_2*) from linear optical parameters (*$\chi^{(1)}$*), n and* E_g *determined.* E_g *and refractive index (n) has been determined directly from the semi-empirical relation proposed by R.R.Reddy. The obtained data shows that the value of* E_g *decreases with the increase of In concentration, while the values of* n_2*, n, (* $\chi^{(3)}$*) and (*$\chi^{(1)}$*) increases with the increase in In concentration.*

Key words:- *Non-linear optical susceptibility and refractive index*

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I. Introduction

Non-linear optical effects in glasses have come in to focus of many researchers because of their potential use in ultra-fast optical switching devices, frequency converters, electro-optic modulators and devices, all optical circuits and all optical signal processing [1-5].

Glasses containing highly polarizable atoms or ions were expected to have large non-linear optical properties namely the chalcogenides (sulphides, selenides and tellurides) have become very interesting [6].

Chalcogenide glasses have been attracted recently a substantial interest as they have highest linear and non-linear refractive index amongst glasses resulting in highest non-linear properties and are of significance in advancing the next generation photonic chips, platform for ultra-fast all- optical signal processing [7].

In the present work we have calculated the non-linear optical parameters in $(Ge_{0.17}Se_{0.83})_{100-X}In_X$ glassy systems and have examined how the non linear refractive index behaves with linear refractive index.

Non-linear Optical Analysis:-

The non-linear refractive index (n_2) can be determined using the semi-empirical relation of Ticha et al [8] as-

$$n_2 = B / E_g^4 \qquad (1)$$

Where $B = 1.26 \times 10^{-9}$ [esu(eV)^4]. Putting the value of E_g [9], we obtain the different values of n_2 for different concentration of In%. The calculated values of n_2 are listed in Table-(1).

Approximate determination of third-order non-linear susceptibility $\chi^{(3)}$ can be performed by using the generalized to Miller"s formula [10-11] as-

$$\chi^{(3)} = A(\chi^{(1)})^4 \qquad (2)$$

Where $\chi^{(1)}$ is the linear optical susceptibility and A is a constant having estimated value 1.7×10^{-10} in (esu)

For amorphous chalcogenide glassy systems the first order approximation of the first order linear susceptibility $\chi^{(1)}$ is calculated by using the following equation-

$$\chi^{(1)} = (n^2 - 1)/4\pi \qquad (3)$$

Where n is the linear refractive index which is calculated by the proposed empirical relation given by Reddy et.al [12-13] as-

$$n = (12.417/E_g - 0.365)^{1/2} \qquad (4)$$

The value of E_g, n, $\chi^{(1)}$, $\chi^{(3)}$ and n_2 are tabulated in Table-(1).

Composition (In%)	**Eg (eV)**	**n**	**$\chi^{(1)}$ (esu)**	**$\chi^{(3)}$ (esu) X 10^{-12}**	**n_2 (esu) X 10^{-11}**
0	2.654	2.3290	0.3522	2.6129	2.541
5	2.584	2.3655	0.3659	3.0464	2.830
10	2.580	2.3676	0.3667	3.0736	2.843
15	2.574	2.3708	0.3679	3.1142	2.866

II. Results and Discussion

There are several ways to estimate $\chi^{(3)}$ from linear refractive index (n), or from optical susceptibility $\chi^{(1)}$ [14].The physically based Miller"s rule, is one of the most convenient especially for visible and near infrared frequencies. The accuracy of Miller"s rule is generally better than an order of magnitude for many covalent or ionic compounds [15-16]. For many halides, oxides and sulphides it agrees with experimental values within a factor of two [17]. The fast component of n_2 and $\chi^{(3)}$ is believed to arises from pure electronic effects. For most transparent materials, the third order non-linearity results from an harmonic terms of the polarization of bound electrons, but the non-linear effects are influenced also by nuclear contributions [18].

In the present work we conclude that the values of n, $\chi^{(1)}$, $\chi^{(3)}$ and n_2 increases with the increase in In concentration where as the value of E_g decreases with the increase in In concentration for the present chalcogenide glassy systems.

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