(Ge0.17Se0.83)100-X InX Chalcogenide glassy systems: Non-linear Optical Analysis

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Abstract
Ge0.17Se0.83 Ternary 100-X Glassy InX Chalcogenide alloys were created using the melt quenching process. Many non-linear optical characteristics were calculated from linear optical parameters ((1)), n, and Eg, including third-order non-linear susceptibility ((3)) and non-linear refractive index (n2). Eg and the refractive index (n) were directly calculated using the semi-empirical relationship R.R. Reddy suggested. The acquired data reveals that while the values of n2, n, ((3)), and ((1)) rise with an increase in In concentration, the value of Eg falls as In concentration increases.
Key words:- Non-linear optical susceptibility and refractive index

Introduction

Due to its potential application in ultra-fast optical switching devices, frequency converters, electro-optic modulators and devices, all optical circuits, and all optical signal processing, non-linear optical phenomena in glasses have drawn the attention of many researchers [1–5].
The chalcogenides (sulphides, selenides, and tellurides) have grown to be particularly fascinating glasses since they were predicted to exhibit considerable non-linear optical features [6].
Chalcogenide glasses are of significance in developing the next generation of photonic chips, platform for ultra-fast all-optical signal processing, and have attracted considerable interest recently. They have the highest linear and non-linear refractive index among glasses, resulting in the highest non-linear properties. [7].
In the present work we have calculated the non-linear optical parameters in $\mathbf{(Ge_{0.17}Se_{0.83})_{100-X}\,In_X}$ 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 x 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 X 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-

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

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

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

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

Composition (In%)	Eg (eV)	n	χ(1) (esu)	χ(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

Results

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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