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LIGHT INDUCED DEFECTS IN AMORPHOUS THIN FILMS OF $Se_{70}Te_{28}Zn_2$.

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Amorphous thin films of $Se_{70}Te_{28}Zn_2$ glassy alloys are prepared by vacuum evaporation technique. These films are exposed to white light of intensity 990 lux at room temperature in a vacuum ~ 10^{-2} Torr. Exposure time is varied from 1 hour to 7 hours. Current- voltage (I-V) characteristics have been measured at various fixed temperatures before and after exposure to light. For this purpose, a dc voltage (0 - 400 V) is applied across the film. I-V characteristics show that, at low electric fields, ohmic behavior is observed. However, at high electric fields, (E ~ 10^4 V/cm), non-ohmic behavior is observed. Using the theory of space charge limited conduction (SCLC), the density of localized states (DOS) has been calculated after each exposure of light. An analysis of the experimental data is used to calculate the DOS. Results indicate that DOS increases with the time of light exposure indicating the creation of light induced defects.

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1. Introduction

It is established that three phenomenon are observed when sample of chalcogenide glasses are illuminated by band gap light [1-3]. These are creation of light induced defects, photodarkning and photo volume expansion. Some glasses show volume contraction as well, for example, Ge-As-Se [4]. In chalcogenide glasses, along with the creation of light induced metastable defects, one also observes photodarkning – a reduction in optical band gap due to band gap illumination [5-7]

Defects play an important role in case of semiconductors as their electronic properties are more sensitive to the presence of defects. The vast utalilization of semiconductors in modern electronics demands an extensive study on the nature of defects present in these semi-conducting materials. As amorphous semiconductors are prepared by rapid cooling of the melt or condensing vapors on cold substrates, many kinds of defects are produced in amorphous materials. The defects density is, therefore, higher in amorphous materials as compared to crystalline materials.

The creation of light induced defects has been observed in a- Si: H which give rise to Staebler- Wronski Effect [8]. It has been observed that on prolong exposure to strongly absorbed light, a large density of metastable defects are created in chalcogenide glasses also [9]

To measure DOS in amorphous semiconductors, different methods [10-15] have been used which have all their advantages and their limitations. Because of the difficulty in forming p-n junctions, spectroscopic methods could not be used for DOS determination. Keeping above aspect in mind, in our previous work, we have used space charge limited conduction (SCLC) experiment for determining DOS in $Se_{70}Te_{30-x}Zn_x$ and observed that DOS increases with the increase of Zn concentration [16]. Similar trend was also observed by thermally stimulated current measurements [17]. In another study, we used SCLC technique to make a comparative study of DOS in bulk as well as in thin films in $Se_{100-x}Bi_x$ glassy system and it was observed that DOS is higher in thin films as compared to bulk samples [18], which is an expected result as defect creation is, in

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general, more in thin films as compared to bulk sample. This shows that a SCLC technique is quite sensitive to monitor the changes of DOS in chalcogenide glasses.

The aim of the present paper is to see the effect of light exposure on DOS in $Se_{70}Te_{28}Zn_2$ thin films. DOS has been calculated using the theory of SCLC before and after exposure to white light. For this purpose, amorphous thin films of $Se_{70}Te_{28}Zn_2$ glassy alloy are exposed to white light of intensity 990 lux at room temperature in a vacuum ~ 10^{-2} Torr and current - voltage characteristics have been measured at various fixed temperatures. I-V characteristics show that, at low electric fields, ohmic behavior is observed and at high electric fields, non-ohmic behavior is observed. It should be pointed out here that exposure times wa varied from 1hour to 7 hours.

2. Experimental details

Glassy alloys of $Se_{70}Te_{28}Zn_2$ are prepared by quenching technique. High purity (99.999 %) materials are weighed according to their atomic percentages and are sealed in quartz ampoules (length ~ 5 cm and internal diameter ~8 mm) with a vacuum ~ 10^{-5} Torr. The ampoules containing the materials are heated to 800 ^{0}C and held at that temperature for 10 hours. The temperature of the furnace is raised slowly at a rate ~ 3 – 4 ^{0}C/min. During heating, all the ampoules are constantly rocked, by rotating a ceramic rod to which the ampoules are tucked away in the furnace. This is done to obtain homogenous glassy alloys. After rocking for about 10 hours, the obtained melts are cooled rapidly by removing the ampoules from the furnace and dropping to ice-cooled water. The quenched samples are taken out by breaking the quartz ampoules.

Thin films of these glasses are prepared by vacuum evaporation technique keeping glass substrates at room temperature. Vacuum evaporated indium electrodes at bottom are used for the electrical contact. The thickness of the films is ~ 500 nm. A planar geometry of the amorphous films (length ~ 1.3 cm, electrode gap ~ 0.12 mm) is used for the electrical measurements.

For the measurements of high field conduction, thin film samples were mounted in a specially designed sample holder where the vacuum ~10^{-2} Torr is maintained throughout the measurements. A d. c. voltage (0 to 400 V) was applied across the sample and resultant current was measured by digital pico-ammeter. I–V characteristics were measured at various fixed temperatures in these films. The temperature of the films was controlled by mounting a heater inside the sample holder and measured by a calibrated copper- constantan thermocouple mounted very near to the films. Before measuring I-V characteristics, thin films were annealed in a vacuum~ 10^{-2} Torr near glass transition temperature for two hours in the same sample holder which is used for current ~ voltage measurements.

3. Results and discussion

A study of I-V characteristics is a matter of importance for property analyzing the conduction mechanism in thin films. In the present paper, I-V characteristics of thin films of $Se_{70}Te_{28}Zn_2$ are examined at various temperatures before and after exposure of light. At low fields (<10^3 V/cm), ohmic behavior is observed in all the samples where I vs. V curves are found to be straight lines. However, at higher fields (~ 10^4 V/cm), non ohmic behavior is observed at all measuring temperatures where ln (I / V) vs V curves are found to be straight lines.

According to the theory of space charge limited conduction, in the case of uniform distribution of localized states, where g (E) = g_0, the current I at particular voltage V is given by the relation [19]:

$$I = (2\, e\, A\, \mu\, n_0 V/d) \exp (S\, V) \tag{1}$$

Where d is electrode spacing, n_o is the density of the thermally generated charge carriers, μ is the mobility, e is the electronic charge, A is the area of cross section of thin films and S is given by:

$$S = 2\, \varepsilon_r\, \varepsilon_o / e\, g_o\, k\, T\, d^2 \tag{2}$$

As evident from equations (1) and (2), a plot of ln I / V vs V should be linear and slope of these lines should decrease inversely with temperature.

In the present case, ln (I / V) versus V curves are found to be straight lines with good correlation coefficient at all the measuring temperatures as shown in Figs.1& 2 for unexposed and light exposed films for exposure time of 1 hour. Similar results are obtained for higher exposure times also.

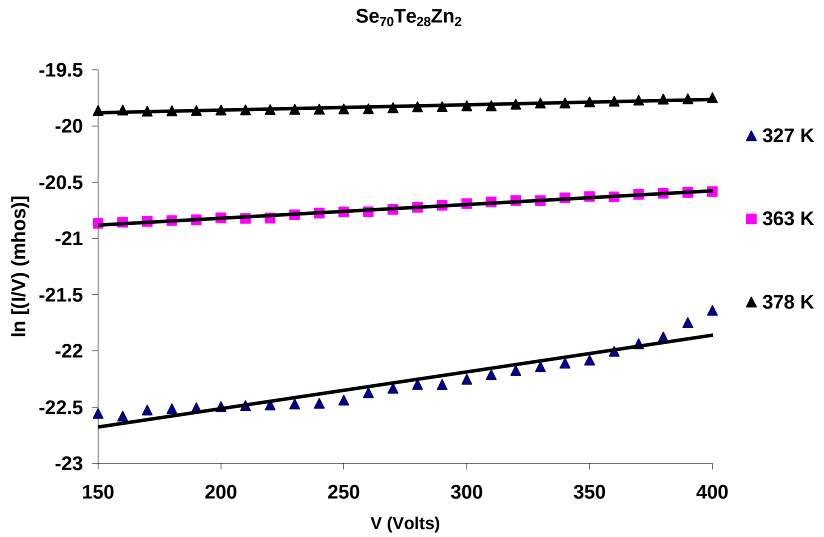

Fig. 1 ln (I / V) versus V plots for $Se_{70}Te_{28}Zn_2$ thin films without exposure of light

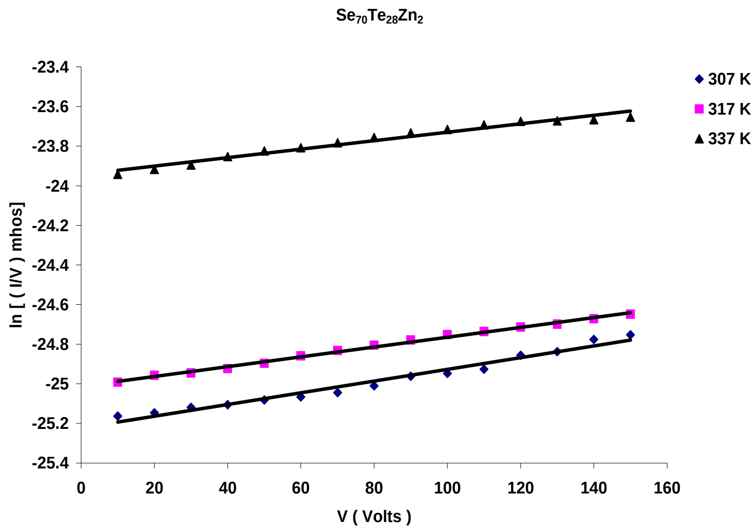

Fig. 2 ln (I / V) versus V plots for $Se_{70}Te_{28}Zn_2$ thin films after exposure of light for 1 hour

Figs 3 & 4 show a plot between the slope of ln (I / V) versus V curve as a function of 1 / T. Such plots are found to be a straight lines. These results indicate the presence of space charge limited conduction in unexposed as well as in exposed samples.

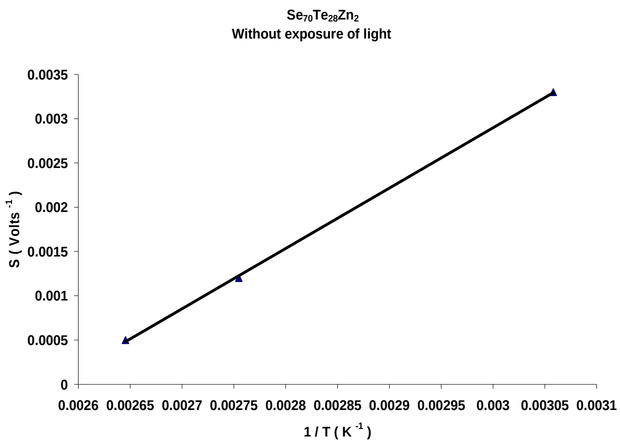

Fig. 3 S versus 1/ T plot without exposure of light

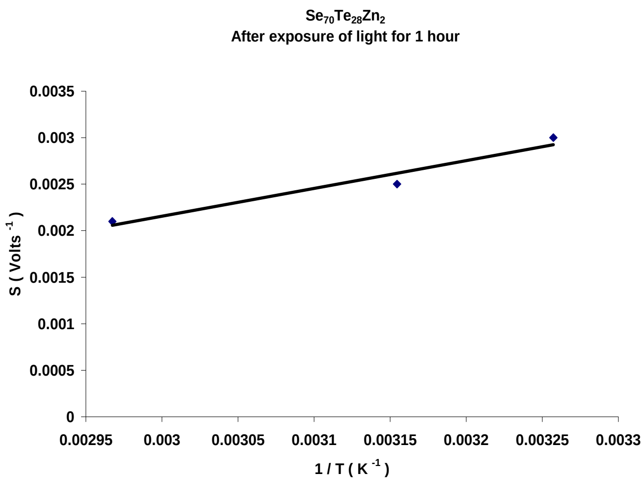

Fig. 4. S versus 1/ T plots after exposure of light for 1 hour

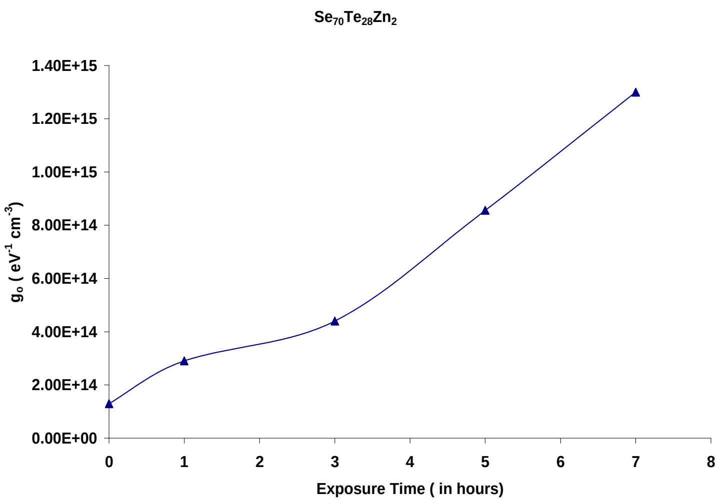

Fig. 5. Variation of density of defects states (g_0) with exposure time.

A thin film contains a large number of defects due to dangling bonds that gives to rise to a large number of localized defects states. These localized states acts as carrier trapping centers, and after trapping the injected charge from electrodes they become charged there by expected to build up a space charge.

We have calculated the density of localized states from the slope of S versus 1/T plots. Here the value of relative dielectric constant ε_r is taken to be 10 which is the dielectric constant value of glassy Se. The results of these calculations are given in Table-1 and plotted in Fig.5 as a function of exposure time. It is clear from this figure that the density of localized states (g_0) increases with the increase of light exposure time.

4. Conclusions

Space charge limited conduction is used to calculate the DOS in amorphous thin films of $Se_{70}Te_{28}Zn_2$. To see the effect of light exposure for longer times on the density of defects, SCLC measurements have been made on exposed samples of various exposure times. The results indicate that DOS increases with the time of exposure. This is interpreted in terms of light created defects as observed in many other experiments in chalcogenide glasses.

Table 1. Calculated density of localized states g_0 for glassy $Se_{70}Te_{28}Zn_2$ before and after exposure of light

Sample (Presence of light)	Exposure time	Slope of S vs. 1/T	g_o(in units of $eV^{-1}.cm^{-3}$)
$Se_{70}Te_{28}Zn_2$	0 hours	6.815	1.30×10^{14}
$Se_{70}Te_{28}Zn_2$	1 hour	3.051	2.91×10^{14}
$Se_{70}Te_{28}Zn_2$	3 hours	2.019	4.40×10^{14}
$Se_{70}Te_{28}Zn_2$	5 hours	1.040	8.56×10^{14}
$Se_{70}Te_{28}Zn_2$	7 hours	0.664	13.40×10^{14}

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