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Composition Dependent Study of AC conductivity in AsSe samples

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Abstract- The room temperature AC conductivity $\sigma(\omega)$ of amorphous AsSe samples with various compositions have been measured in the 10^3 -10^6 Hz frequency range. The results indicate that ac conductivity is proportional to ω^n with n=0.89±.01 in the 10^3 –10^6 Hz frequency range. Consideration of different models for the frequency –dependent conductivity leads to thermally activated hopping as the most likely process.

Index Terms- ac conductivity, AsSe glass system, hopping model, frequency.

I. Introduction

Chalcogenide glasses that form an important class of amorphous solids have very interesting physical properties and can be prepared in the bulk as well thin films. Measurement of ac conductivity of amorphous chalcogenide semiconductors has been extensively used to understand the conduction process in these materials [1]. The conductivity of semiconducting glasses is known to be frequency dependent what as expected, is due to conduction between localized states Generally, the undoped chalcogenide glasses show low values of electrical conductivity, which could mean a serious limit to their technological application and electrical measurements. Certain additives are used to improve these properties [2-5]. In recent years the application of these materials as photoconductors in xerography, as memory switching elements, inorganic photo resist, IR detection and transmission etc has been accompanied by substantial interest in their physical properties.

Arsenic-containing chalcogenides, especially the Se-rich alloys, are among the most intensely studied glassy semiconductors. This interest has been motivated by the unique physico-chemical properties of these glasses, e.g. high transmission in the mid-infrared region or very good glass-forming ability allowing the amorphous material to be shaped into various optical devices. As a consequence, applications of As–Se glasses, employing bulk material as well as thin films or fibers, have won recognition in numerous civil, medical and military areas. The photo generation and charge transport mechanism were studied in detail in As-Se alloy system. It is found that both photo generation and charge transport were discovered to be field dependent at room temperatures. In these materials, electrons were found to be localized, while holes exhibited a distribution of field dependent motilities. Carriers can move between these localized states only by phonon assisted hopping. This is an important transport mechanism in amorphous and molecular solids. Additional information about localized states can be gained from ac conductivity measurements. This conductivity due to hopping between localized states was shown to be proportional to ω^n where $n \leq 1$. We report here the room temperature measurements of the frequency dependent conductivity of AsSe sample with various compositions in the frequency range 10^3-10^6 Hz.

II. Experimental Procedure

The samples in the bulk form for present investigation have been prepared by the melt quenching technique. The capacitance (C) and dielectric loss factor (tanδ) of the samples were measured, using Fluke PM6306 Impedance analyzer. All the measurements were done at room temperature in the 10^3-10^6 Hz frequency range. Sample under study were of the composition $As_{15}Se_{85}$, $As_{20}Se_{80}$, $As_{25}Se_{75}$ and had a thickness ranging from 1 to 0.7mm.

The sample is placed in dielectric cell, mounted between two gold plated copper disc electrodes. One of the discs is kept fixed and another disc is kept in position using perfect spring contact. Electrical connections were taken from this contact. After placing the sample,the dielectric cell is evacuated using a rotary pump. The capacitance and dissipation factor of the sample is measured in the frequency range 10^3-10^6 Hz. From the capacitance measured the Dielectric constant or relative permittivity were calculated using the formula

$$\in_r = C\times d / \in_0 \times A \qquad (1)$$

where d is the thickness of the sample, C is the Capacitance and A is the area of cross section of the sample,$\in_r$ is the relative permittivity of the sample which is a dimensionless quantity , $\in_0$ is the vacuum permitivity. The ac conductivity of the sample were then calculated using the formula

$$\sigma_{a.c} = 2\pi f \tan\delta \in_0 \in_r \qquad (2)$$

Where f is the frequency, tanδ dielectric loss factor obtained from the impedance analyser.

III. Results and Discussion

Frequency dependent ac conductivity in the 10^2-10^8Hz ranges has been observed previously for As_2Se_3 samples [6]. The frequency dependent conductivity is given by $\sigma(\omega) = A\omega^n$ where A is a constant and $0.8 \leq n \leq 1$ at room temperature. In our measurements the range of values for n is 0.89 ±. 01. The ac conductivity measured at room temperatures for the frequency range10^3-10^6Hz is shown in Fig.1

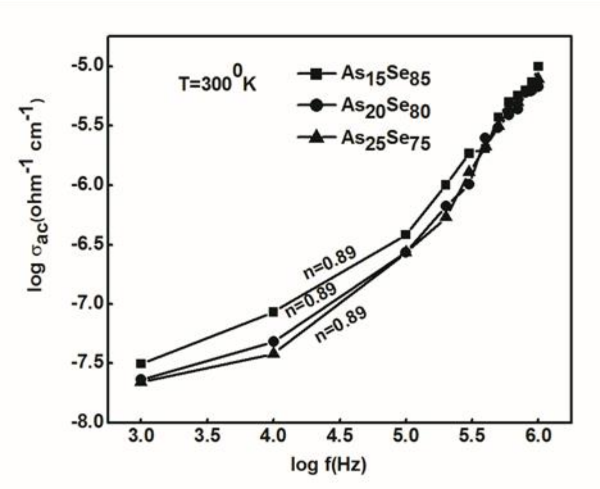

Fig.1.Frequency dependence of the conductivity at 300°K of AsSe samples

It is found that the measured value of *n* agrees well with the cited values [6]. It has been customary to explain frequency dependence of $\sigma(\omega)$ in terms of a hoping-transport model. Hopping-type conduction between localized states may be tail states or states at the middle of the gap [N (E_F)]. Pollak and Geballe (PG) [7] formulated a treatment, which accounts for the experimental results in the case of hopping between impurity states. PG have shown that if hopping takes place between a random distribution of localized states, then $\sigma(\omega) \propto \omega^n$ where $0.5< n <1$, the lower value of n occurs for multiple hops while the higher value occurs for single hops. Since the hopping process is phonon assisted, a small but finite temperature dependence in $\sigma(\omega)$ should exist even at low temperatures. According to Pollak at higher temperatures, multiple hops occur frequently, while at low temperatures single hop predominates. This leads to an increased thermal activation at higher temperature, with a corresponding decrease in the frequency dependence.

Using the theory of PG, Austin and Mott [8] derived a theoretical formula for $\sigma(\omega)$ which is proportional to [N(E_F)] [7], the density states at the Fermi level close to the middle of the mobility gap. They conclude that this band of compensated states pins the Fermi level near the middle of the gap, and that N (E_F) increases with decreasing mobility gap, due to the greater overlap of tail states. N (E_F) also is predicted to increase with increasing disorder.

A fuller description of hopping can account more realistically for the temperature dependence of $\sigma(\omega)$. Thus to substantiate hopping as the dominant transport mechanism it is important to understand the complete frequency and temperature dependence of $\sigma(\omega)$ in terms of a more general theory of ac hopping transport

IV. CONCLUSION

Ac electrical conductivity measurement has been carried out in three different compositions in As-Se glass systems. It is found that conductivity frequency relation has an exponent of ≈0.89, which agrees for the results for As_2Se_3 system reported earlier. The conductivity relation is explained based on hopping conduction

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